U.S. Department of the Interior
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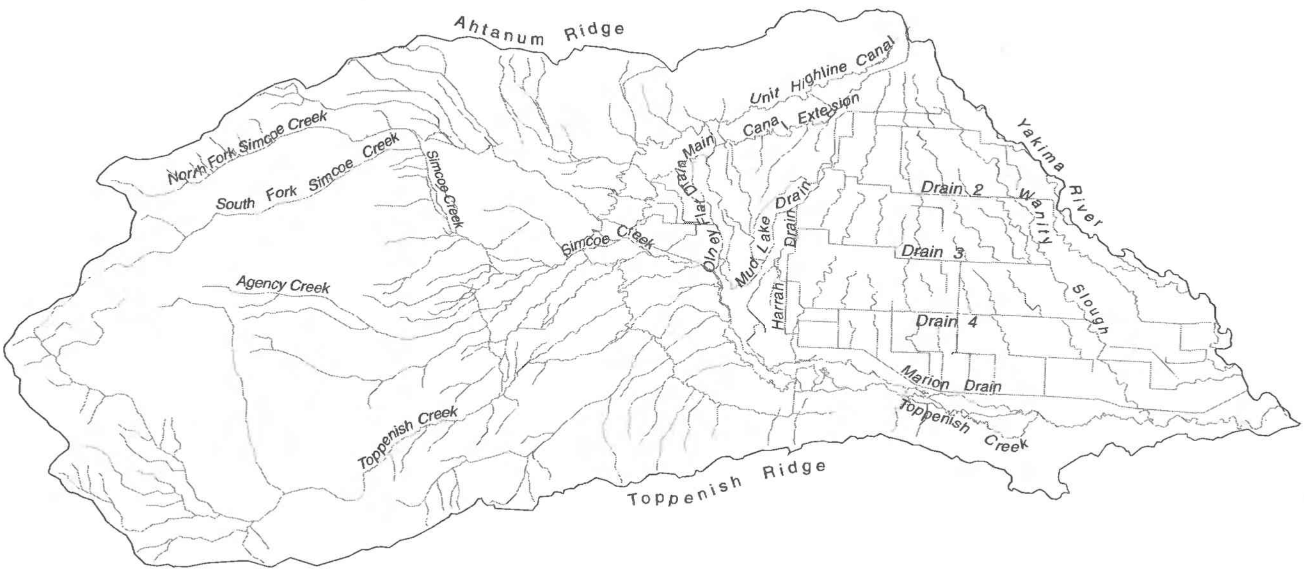
A Survey of Ground-Water Quality in the Toppenish Creek Basin, Yakama Indian Reservation, Washington, 1989-91

Water-Resources Investigations Report 97-4194



Prepared in cooperation with
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By S. S. Sumioka

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Tacoma, Washington
1998

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
acre	0.4047	hectares
square mile (mi^2)	2.590	square kilometer
gallon (gal)	3.785	liter
acre-foot (acre-ft)	1,233	cubic meter
gallon per minute (gal/min)	0.06308	liter per second

Temperature: To convert temperature given in this report in degrees Fahrenheit (^oF) to degrees Celsius (^oC), use the following equation: $^oC = 5/9\ (^oF-32)$.

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

Ground-water quality in the Toppenish Creek Basin, near Yakima, Washington, is generally good with respect to U.S. Environmental Protection Agency drinking water standards. Of 487 wells sampled during one phase of the study, only 2 produced water with nitrite-plus-nitrate concentrations greater than the U.S. Environmental Protection Agency standard of 10 milligrams per liter as nitrogen. Ground-water samples with elevated nitrite-plus-nitrate concentrations (greater than 5 milligrams per liter as nitrogen) were obtained from wells located in the eastern and southern parts of the basin and in areas underlain by the Touchet Beds, in the central part of the basin. In another phase of the study, in which 60 wells were sampled, atrazine, an herbicide used on asparagus and corn, was detected in water samples from 4 wells, and 2 insecticides, diazinon and disulfoton, were detected in separate samples from 2 wells.

Bacteria, indicators of the sanitary water quality, were detected in samples from 64 wells, suggesting that ground water may be contaminated in some areas. However, other sources of bacteria may include leaks in the plumbing of the well or residence, or improper well construction.

Small seasonal variations in nitrite-plus-nitrate concentrations in ground water appeared to be related to fertilizer use in the basin, indicating that the potential exists for more serious contamination of ground water. Ground-water quality is affected by agricultural activities in some parts of the basin. However, widespread degradation in ground-water quality was not detected.

INTRODUCTION

People in the Toppenish Creek Basin rely exclusively on ground water for their potable water supply. Available ground-water-quality data (Wittman and Armstrong, 1989) indicate that some ground water is contaminated with nitrite-plus-nitrates. Because the concentration of nitrite is generally negligible in comparison to nitrate, nitrite-plus-nitrate is assumed to be equivalent to nitrate, and is referred to simply as nitrate in this report. Water supplies may also contain contaminants derived from agriculture, domestic wastes, food processing, and a few light industries in the basin.

The U.S. Geological Survey (USGS) began a study in 1989 to define ground-water quality within the basin, to identify existing and potential water-quality problems, to attempt to relate ground-water-quality conditions to geohydrology, and to attempt to identify source areas and flow paths of contaminants that are or may cause water-quality problems.

This work was done in cooperation with the Yakama Indian Nation (YIN) and was funded by the USGS, YIN, and the Washington State Department of Ecology (Ecology). The study was done in four steps: (1) Determine water and land use and population density and distribution in the Toppenish Creek Basin; (2) sample water from about 500 wells and 50 surface-water sites to determine nitrate concentrations and fecal-coliform, fecal-streptococcus, and *Escherichia coli* (*E. coli*) bacterial concentrations; (3) sample water from 20 wells every 6 weeks for 1 year for the same constituents as in step 2; (4) sample water from 15 of the 20 wells from step 3 twice (early spring and late summer, 1991), and from 4 more of the 20, plus 41 other wells, once (late summer, 1991) to analyze for major ions, trace elements, and pesticides. In addition to this report, the results of this study will be presented at public meetings to be held in the Toppenish Creek Basin. In this report, step 2 is referred to as the synoptic sampling program, step 3 is referred to as the seasonal sampling program, and step 4 is referred to as the intensive sampling program.

Data compiled on water and land use, and population density and distribution (step 1) were published in 1991 (Yakima Indian Nation, 1991). Concentrations of nitrate and bacteria in ground water and surface water (step 2) were published by the USGS in 1994 (Payne and Sumioka, 1994).

In 1994, the Yakama Indian Nation changed the spelling of the tribal name from "Yakima" to "Yakama." In this report, all references to the Yakama Indian Nation reflect this change. However, for geographic locations and in references to published reports, the former spelling (Yakima) is used.

Purpose and Scope

The purpose of this report is to present the results of the ground-water sampling program designed to characterize ground-water quality in the Toppenish Creek Basin. These results were used to identify existing or potential water-quality problems, attempt to relate ground-water-quality conditions to the geohydrology of the basin, and attempt to determine the source areas and flow paths of constituents that are causing or may cause water-quality problems. Land and water use and population data were presented in the first report of the study (Yakima Indian Nation, 1991) and the results of the synoptic sampling program were presented in the second report (Payne and Sumioka, 1994).

This report presents data from the seasonal and intensive sampling phases (steps 3 and 4) and summarizes the general ground-water quality in the Toppenish Creek Basin on the basis of data collected during steps 2, 3, and 4.

About one-third of the Toppenish Creek Basin (mostly west of White Swan, fig. 1) is closed to agriculture; therefore, most of the water samples collected during this project were from wells and surface-water sites in the eastern two-thirds of the basin. This area corresponds roughly to those parts of the basin where young valley fill and old valley fill are exposed at land surface.

Data from drillers' logs and published reports were used to determine the geohydrology of the basin; published data from previous studies were used to determine ground-water flow paths. The Water Resources Planning Program (WRPP) of the Yakama Indian Nation provided data on land, water, and pesticide use in the basin.

Previous Investigations

The USGS (1975) described three major aquifers underlying the Toppenish Creek Basin: the basalt aquifer, the old valley fill aquifer, and the young valley fill aquifer. Water levels in wells tapping the basalt aquifer indicated ground-water flow was eastward, toward the Yakima River. Water levels in wells tapping the old valley fill and young valley fill aquifers indicated that ground-water flow was southeastward toward the confluence of Toppenish Creek and the Yakima River.

Bentley and others (1980) discuss the stratigraphy and structure of the geologic units underlying the basin. The emphasis of that report is on identifying the Yakima Basalt Subgroup underlying the Yakama Indian Reservation. However, they also discussed the sedimentary rocks of the Ellensburg Formation; the unconsolidated deposits of the Touchet Beds (Flint, 1938) left by the backwater of the flood that formed the channeled scablands; and the unconsolidated deposits of clay, silt, sand, and gravel laid down by the Yakima River and by Toppenish, Agency, and Medicine Creeks.

Historical Water Quality

Sylvester and Seabloom (1962) investigated irrigation return flows in the Yakima River Basin. That study, which included two wells and three surface-water sites within the Toppenish Creek Basin, found that ground water in irrigated areas had a salt content about five times higher than that of adjacent surface water; that percolation of irrigation water through the unsaturated zone improved the physical and bacteriological quality of return flows, but leaching and ion exchange processes increased the concentration of several chemical constituents; and that the water quality of the Yakima River was affected more by irrigation return flows than by domestic and industrial discharges.

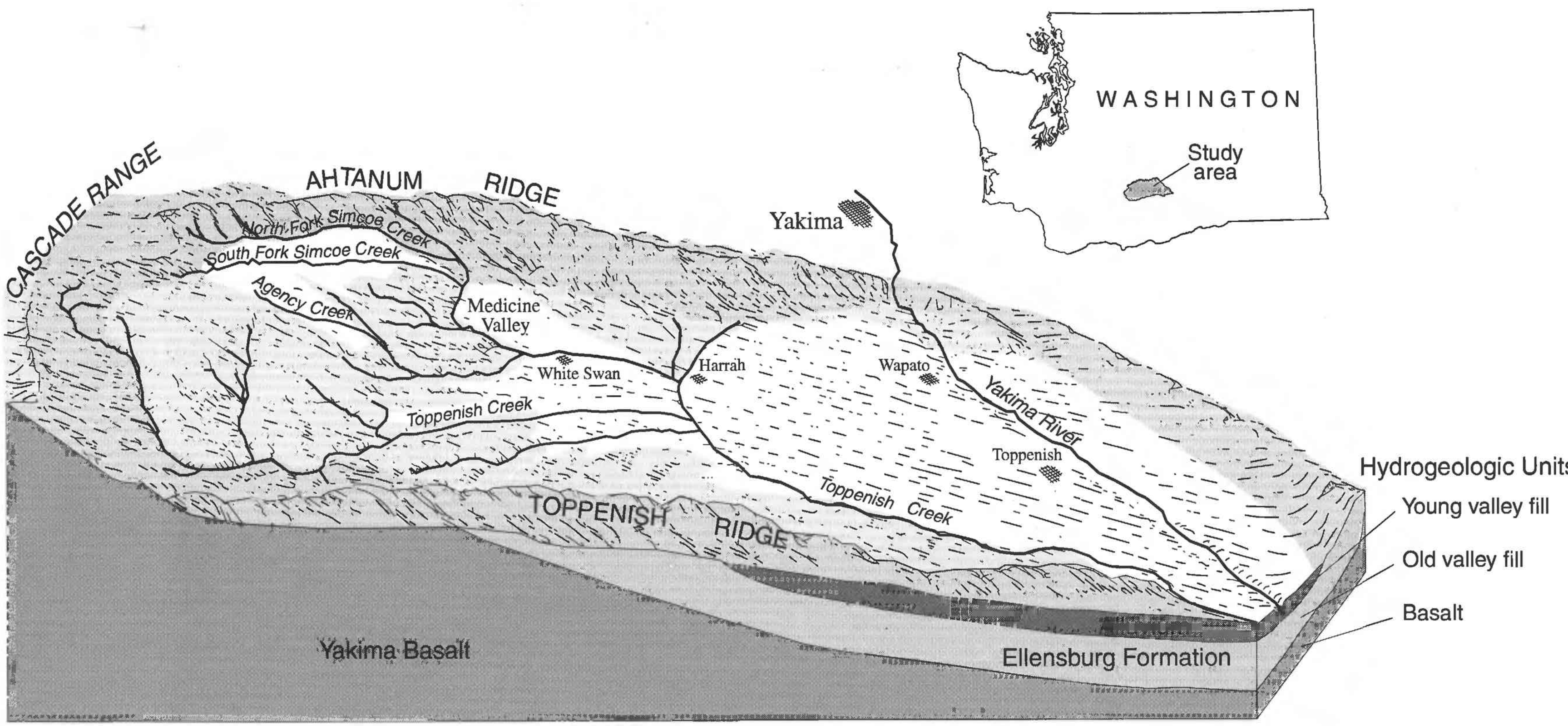

Figure 1. Location and generalized surficial geology of the Toppenish Creek Basin, Washington.

A few studies have described the ground-water quality of the Toppenish Creek Basin. Van Denburgh and Santos (1965) included data from two City of Toppenish wells in their statewide compilation of selected ground-water-quality data. From the two wells, the largest nitrate concentration was 2.0 mg/L (milligrams per liter) as nitrogen. In this report, all concentrations given for nitrogen species are as nitrogen.

An extensive study by Fretwell (1979) included 313 wells and springs in the Toppenish Creek Basin. In general, calcium and bicarbonate were the predominant cation and anion in solution, respectively. Percent calcium was found to be higher in samples from alluvial wells (young valley fill) than in samples from wells in old valley fill or basalt. Nitrate concentrations ranged from less than 0.1 mg/L to 20 mg/L for samples from all wells in the basin. Samples of water from the young valley fill (257 wells) had the largest mean concentration of nitrate of 1.9 mg/L; samples from the old valley fill (20 wells) averaged 0.67 mg/L; and samples from basalt wells (36 wells) averaged 0.20 mg/L. No ground-water samples were analyzed for pesticides.

Surface-water quality also was investigated by Fretwell (1979). Twelve stations were sampled in the Toppenish Creek Basin at frequencies ranging from monthly for 1 year to only once. The results generally indicated that surface-water quality was a function of land use in the contributing drainage area. Mountain streams, where the influence of human activities was low, were found to have smaller dissolved-solids concentrations, larger concentrations of dissolved oxygen, and smaller concentrations of nitrates than the lowland streams (which included canals and drains). Limited time for water-rock interaction may also play a part in the smaller dissolved-solids concentrations found in samples from the mountain streams.

Turney (1986) included data for 56 wells in the Toppenish Creek Basin in an assessment of ground-water quality for the southeastern and south-central portions of Washington State. Nitrate concentrations were available for 52 of the wells; the median concentration was 0.74 mg/L, and the minimum and maximum concentrations were less than 0.1 mg/L and 15.0 mg/L, respectively, for those 52 wells. The maximum concentration was found in a sample collected from a well near Harrah, Wash.

Wittman and Armstrong (1989) found nitrate concentrations greater than 2.5 mg/L in ground water from the southeastern part of the basin and in the south-central part of the basin. They also found that mean nitrate concentrations increased immediately following the irrigation season and then gradually decreased until the start of the next irrigation season. When they compared their data with data collected by the USGS in 1974 (Fretwell, 1979), they determined that the mean nitrate concentration from water samples from the young valley fill had increased from about 2 mg/L in 1974 to about 3.2 mg/L in 1988, and those from the Touchet Beds had increased from about 1 mg/L to about 3 mg/L during the sampling period. In their study, Wittman and Armstrong (1989) subdivided Fretwell's (1979) alluvial aquifer into four units: young valley fill, recent alluvial gravels deposited by the Yakima River; Touchet Beds, catastrophic flood deposits found primarily in the central part of the basin; Toppenish Creek Alluvium, made up primarily of deposits from Toppenish Creek; and Medicine Valley Alluvium, made up of deposits carried by Medicine Creek.

Well-Numbering System

The well-numbering system used by the USGS in the State of Washington is based on rectangular subdivisions that identify wells within a township, range, section, and 40-acre tract within the section. A well number, such as 11N/18E-24C01, indicates that the well is in township 11 north of the Willamette base line, and range 18 east of the Willamette meridian. The first number following the hyphen (24) indicates the section, and the letter (C) gives the 40-acre tract within the section. The two-digit number (01) following the letter indicates that this well was the first well in the 40-acre tract entered into the USGS well data base. Well numbers showing a "D" indicate a deepening of the well. In some illustrations of this report, wells may be identified only by the last part of the well number (for instance, 24C01) for easier visual representation.

DESCRIPTION OF THE STUDY AREA

Toppenish Creek, a tributary of the Yakima River in south-central Washington (fig. 1), drains about 630 square miles, all of which lie within the boundaries of the Yakama Indian Reservation. The drainage basin is bounded on the north and south by the Ahtanum and Toppenish Ridges, respectively, on the west by the topographic divide with the Klickitat River Basin, and on the east by the Yakima River. The altitude in the basin ranges from about 6,000 feet in the western uplands to about 700 feet at the Yakima River, near Toppenish, Wash.

Most of the land west of White Swan is forested or is used as arid range land. Land in the eastern part of the basin is flat and is used primarily for irrigated agriculture. Major crops grown in the basin include apples, pears, hops, grapes, potatoes, corn, asparagus, mint, and alfalfa. Most of the water for irrigation comes from the Yakima River through a system of canals; however, ground water from deep wells tapping aquifers in basalt and sedimentary rocks is also used for irrigation in some parts of the basin.

The Toppenish Creek Basin is the most densely populated and most heavily used agriculturally (Fretwell, 1979). A separate report describes the population distribution and land and water use in the basin (Yakima Indian Nation, 1991).

Climate

The eastern part of the Toppenish Creek Basin exhibits a continental climate, characterized by hot, dry summers and cold, dry winters. During the summer, daytime temperatures generally range from 80°F (degrees Fahrenheit) to over 100°F. Daytime temperatures during the winter generally range from 30°F to 40°F (Donaldson, 1979). Annual precipitation ranges from over 50 inches in the western highlands to about 5 inches near the Yakima River (Pacific Northwest River Basins Commission, 1969, p. A-29). Mean annual precipitation at Wapato, Wash., for 1961-93 is 7.5 inches (U.S. Department of Commerce, 1994).

Land Use

In 1989, about 50 percent of the basin (213,300 acres) was used for agriculture. Pasture and range land accounted for about 25 percent of the agricultural land use. Forage and grain crops such as wheat, alfalfa, and hay accounted for about 14 percent; vegetable crops such as corn, beans, and asparagus accounted for about 9 percent; and orchard crops such as apples, peaches, and pears accounted for about 7 percent (Yakima Indian Nation, 1991). The remaining arable land in the basin was used for garden crops such as melons, onions and peppers (1.5 percent); grapes (2.0 percent); hops (3.6 percent); mint (5.1 percent); or was idle (31 percent). Most of the remaining 50 percent of the basin is closed to domestic or agricultural development (Yakima Indian Nation, 1991).

The amount of nitrogen fertilizer applied in the basin during 1989 totalled about 6,920 tons (Yakima Indian Nation, 1991; Small and Jameson, 1989). The application rates ranged from 50 lbs/acre (pounds per acre) for grapes to 441 lbs/acre for alfalfa (Yakima Indian Nation, 1991).

Other land uses in the basin include processing plants for fruits, vegetables, and livestock; residential (including schools and parks) and commercial; and light industry such as fertilizer manufacturing.

Water Use

The main use of water in the Toppenish Creek Basin is irrigation. About 660,000 acre-ft (the volume of water that can cover one acre at a depth of one foot) of surface water and about 47,000 acre-ft of ground water were used for irrigation in 1990 (Yakima Indian Nation, 1991). Water diverted from the Yakima River by a dam at Parker, Wash., is distributed to the interior of the basin through a system of canals. Most irrigation wells are located in the western part of the basin and on the lower slopes of Ahtanum and Toppenish Ridges. Almost all of the irrigation wells draw water from the deeper aquifers (basalt and old valley fill).

Non-agricultural uses (drinking and domestic uses, food processing, and other commercial uses) required about 5,000 acre-ft of ground water in 1990 (Yakima Indian Nation, 1991). No surface water is used for these purposes. Most of the wells used for these purposes draw water from the shallow aquifers (young valley fill).

GEOHYDROLOGY

Geologic units in the Toppenish Creek Basin have been grouped into three major aquifers, based on their hydrologic characteristics (U.S. Geological Survey, 1975): the young valley fill aquifer, which includes all of the unconsolidated material in the basin and, in places, the upper, partially consolidated part of the Ellensburg Formation; the old valley fill aquifer, which includes the remainder of the Ellensburg Formation overlying the youngest Columbia River Basalt layer; and the basalt aquifer, which includes the basalt flows and the sedimentary interflow layers or zones (table 1).

Table 1.--*Stratigraphic relations and hydrologic characteristics of the geologic units in the Toppenish Creek Basin, Washington (U.S. Geological Survey, 1975)*
[ft, feet; (gal/min)/ft, gallons per minute per foot; acre-ft, acre-feet]

Geologic units	Maximum thickness (feet)	Origin and lithology	Hydro-geologic units	Hydrologic characteristics	Remarks
Alluvium	150	Deposited by the Yakima River and Toppenish Creek, consisting of coarse gravel, sand, silt, and cemented gravel. Near base deposits are finer grained and similar to Ellensburg Formation	Young valley fill	Generally yield water freely, specific capacities range from 14 to 58 (gal/min)/ft.	Potentially the most productive and manageable aquifer, presently the least developed. 1970 pumpage was about 5,900 acre-ft.
Touchet Beds of Flint (1938)	35	Varied lacustrine silts, clays, and fine sands.		Very poor drainage characteristics, acts as a confining layer in some areas.	Not suitable for water supplies.
Ellensburg Formation	1,000	Partially consolidated fluviatile-lacustrine deposits. Conglomerate interbedded with sandstone, siltstone, and gravel in upper parts of formation. Partially consolidated thick silt and silty clay and clay in the central part of the formation. Partially consolidated coarse sand and gravel interbedded with finer sediments in the lower parts of the formation. Base interbedded with the Saddle Mountains Member of the Yakima Basalt	Old valley fill	Yields water from upper and lower parts of the formation. Specific capacities range from 3 to 28 (gal/min)/ft. Lower aquifer zones are under artesian pressure in the eastern parts of the Toppenish Basin, heads range up to several tens of feet above land surface.	An important aquifer present over most of the irrigable acreage in the Toppenish Basin. Present use is slightly greater than that of the alluvium. Potential for management is not as high as for alluvium due to depths of aquifer and the presence of thick confining layers in the Ellensburg Formation. 1970 pumpage was about 6,500 acre-ft.
Yakima Basalt: Saddle Mountains Member					
Yakima Basalt: Priest Rapids Member; Mabton Interbed of Mackin (1961); Quincy Diatomite Bed; Roza Member; Squaw Creek Diatomite Bed; Frenchman Springs Member; Vantage Sandstone Member; Undifferentiated basalt	over 1,200	Lava flows. Hard, dense basaltic rocks. Individual flows range up to 100 ft in thickness. Interflow zones may be rubbly, and several have fine-grained sediments of variable thickness. Flows have varying degrees of vertical jointing, usually columnar though some are more irregular.	Basalt	Yields water mainly from interflow zones which may compose 20 to 30 percent of the section penetrated by a well. Yields are highly variable, specific capacities range from less than 1 to over 400, but average about 16 (gal/min)/ft. Near the margins of the basin the basalt flows have been folded and faulted. This structural deformation frequently reduces the aquifer's capacity to transmit water as the permeable interflow zone becomes pinched off by folding or displaced by faulting.	The most widely distributed aquifer, underlying the entire basin. Presently the most used aquifer, 1970 pumpage was about 16,000 acre-ft. Poor management potential due to depths, and impracticality of recharging the aquifer system.

The young valley fill is an unconfined aquifer located in the eastern one-third of the basin. However, the Touchet Beds of Flint (1938), where they exist, act as a confining layer within the aquifer. Recharge occurs primarily from infiltration and percolation of precipitation and irrigation water. At the southern and eastern boundaries of the young valley fill, water enters the aquifer from underlying old valley fill. During periods when water levels in the Yakima River are higher than the water table, river water can enter the aquifer. Water leaves this aquifer by direct subsurface discharge to Toppenish Creek and the Yakima River, by discharge to artificial drains in the agricultural areas, by pumpage from wells, and, along parts of Toppenish Creek, by transpiration from plants. Some water is also lost in the northern part of the basin by leakage to the underlying old valley fill.

The old valley fill is the second most extensive aquifer in the basin. This aquifer is unconfined where it is within 50 feet of land surface. The aquifer is confined where it is overlain by more than 50 feet of young valley fill, such as near the center of the basin. The aquifer is recharged with water from precipitation, with excess irrigation water that has percolated below the root zone, by leakage from overlying young valley fill, and, in the southeastern part of the basin, by upward leakage from the underlying basalt aquifer. Water leaves the old valley fill as discharge to the underlying basalt in the western part of the basin, as leakage to the overlying young valley fill in the southern and eastern parts of the basin, as lateral flow under the Yakima River, and by pumpage from wells.

The basalt aquifer is the most extensive in the basin; however, wells in basalt are located primarily in the central one-third of the basin, bordering the western edge of the lowland area. Yields vary from less than 50 gal/min (gallons per minute) to more than 2,000 gal/min. The variation is due to the uneven distribution of fractures in the basalt and to variations in the extent of the interflow zones between the basalt flow units that are the principal avenues of horizontal water movement in this aquifer (U.S. Geological Survey, 1975). Water enters the basalt as precipitation in the western upland area and along the flanks of Ahtanum and Toppenish Ridges, and, in the western part of the lowland area, as leakage from overlying old valley fill. Water leaves the basalt by moving upward into the old valley fill in the southeastern part of the basin, by pumpage from wells, and by moving eastward under the Yakima River.

Potentiometric contours indicate that ground-water flow in the basalt aquifer is generally southeastward from Ahtanum Ridge and eastward from the Cascade Range foothills toward the Yakima River. In the southeastern part of the basin, some ground water may flow in a northeasterly direction toward the Yakima River (fig. 2). Ground-water flow directions in the deep, confined part of the old valley fill aquifer are similar to flow directions in the basalt aquifer: southeastward from Ahtanum Ridge, eastward from the Cascade Range foothills, and northeastward toward the river from the southeastern part of the basin (fig. 3). Ground-water flow in the young valley fill and unconfined old valley fill is generally eastward and southeastward (fig. 4).

METHODS

Details of site selection, sampling, and quality assurance-quality control procedures are given in a study by the Yakima Indian Nation (1988). In all cases, standard USGS sampling and analytical methods were used throughout this study.

Site Selection

The characteristics used to select wells to be sampled during the synoptic sampling program were well depth, well location, lithology, and well-construction information. Data for these characteristics were obtained from drillers' logs filed with the State of Washington or with the Indian Health Service in Toppenish. Because most of the ground water used for domestic purposes comes from the unconsolidated and partially consolidated sediments, most of the wells selected for sampling are completed in these materials (422 wells). Sixty-two wells that tap the basalt aquifer were also selected. (Three wells were sampled for which drillers' logs could not be found. These wells are not included in the following discussions.) The locations of the selected wells, the aquifer unit in which those wells are completed, and the sampling phase in which the wells are included are shown on plate 1. Domestic wells with the highest nitrate concentrations were selected for sampling during the seasonal phase. Wells selected to be sampled during the intensive sampling program were primarily those in which elevated nitrate concentrations were found during the earlier sampling phases (synoptic and seasonal). Nineteen of the 20 wells sampled during the seasonal phase were also sampled at least once during the intensive sampling phase. Changes in well construction at the twentieth well prevented inclusion of it in the intensive sampling phase; therefore, another nearby well was substituted.

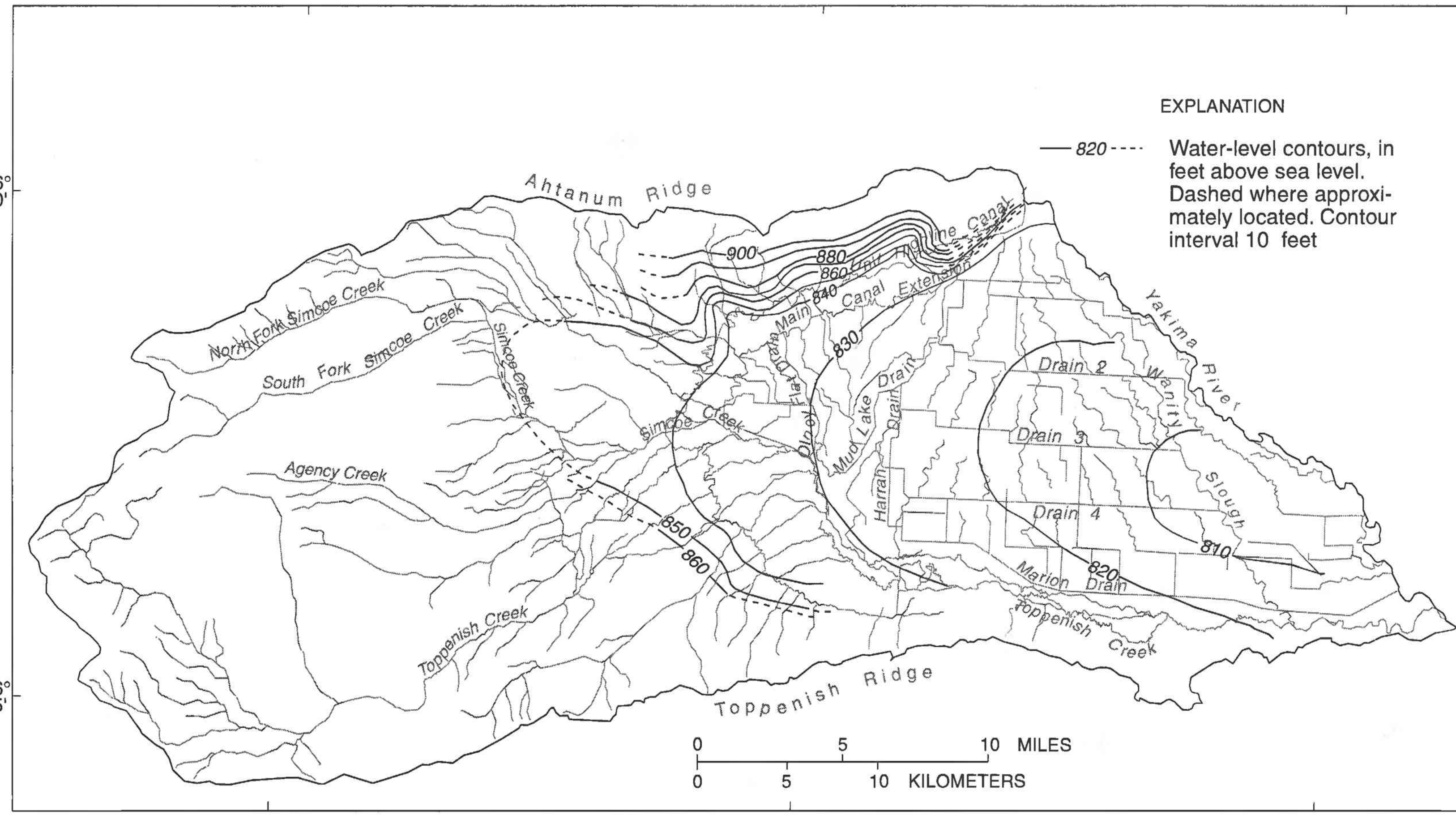

Figure 2. Water-level contours in the basalt aquifer, March 1972 (from U.S.Geological Survey, 1975).

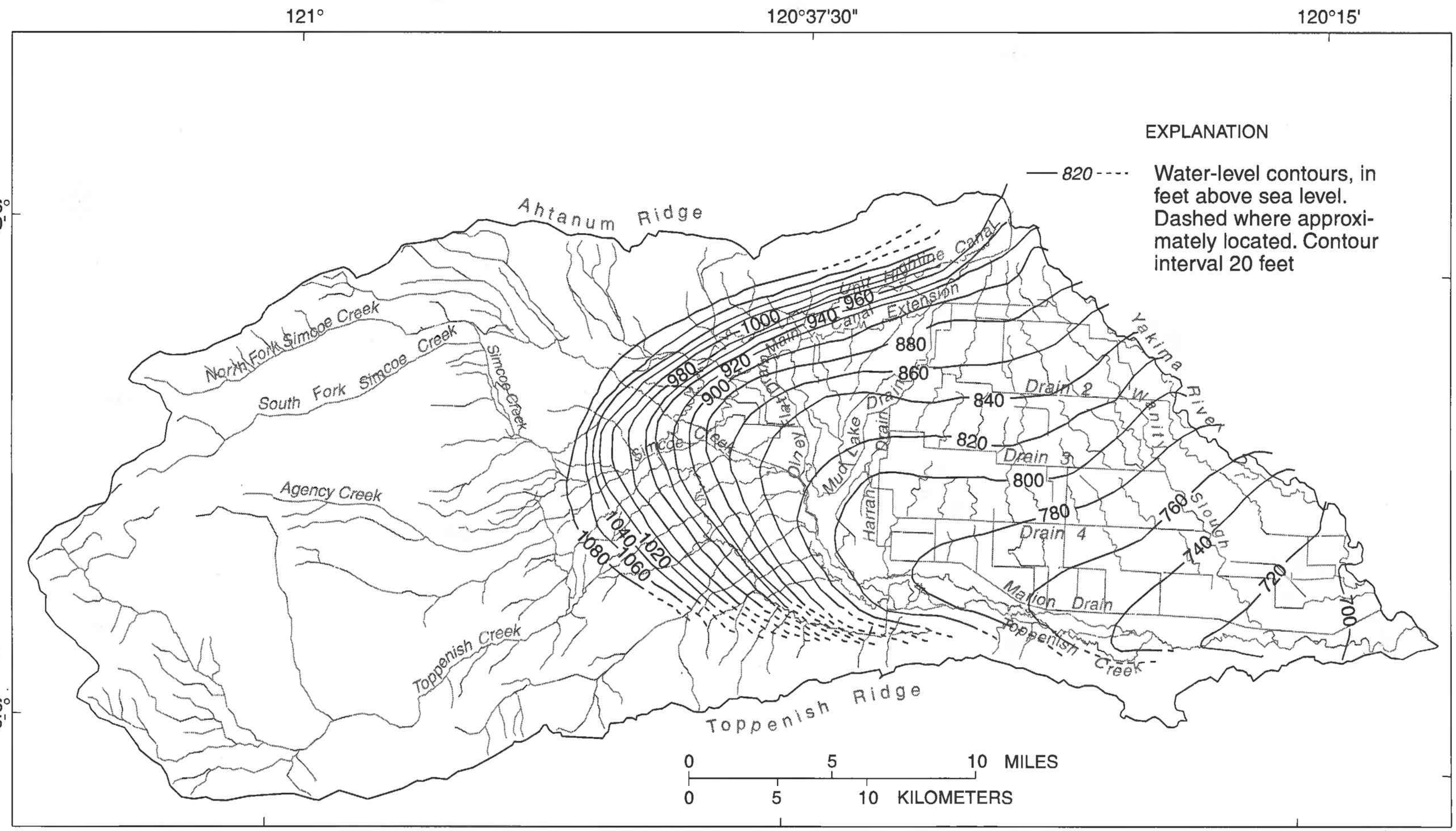

Figure 3. Water-level contours in artesian zones in the old valley fill aquifer, March 1972 (U.S. Geological Survey, 1975).

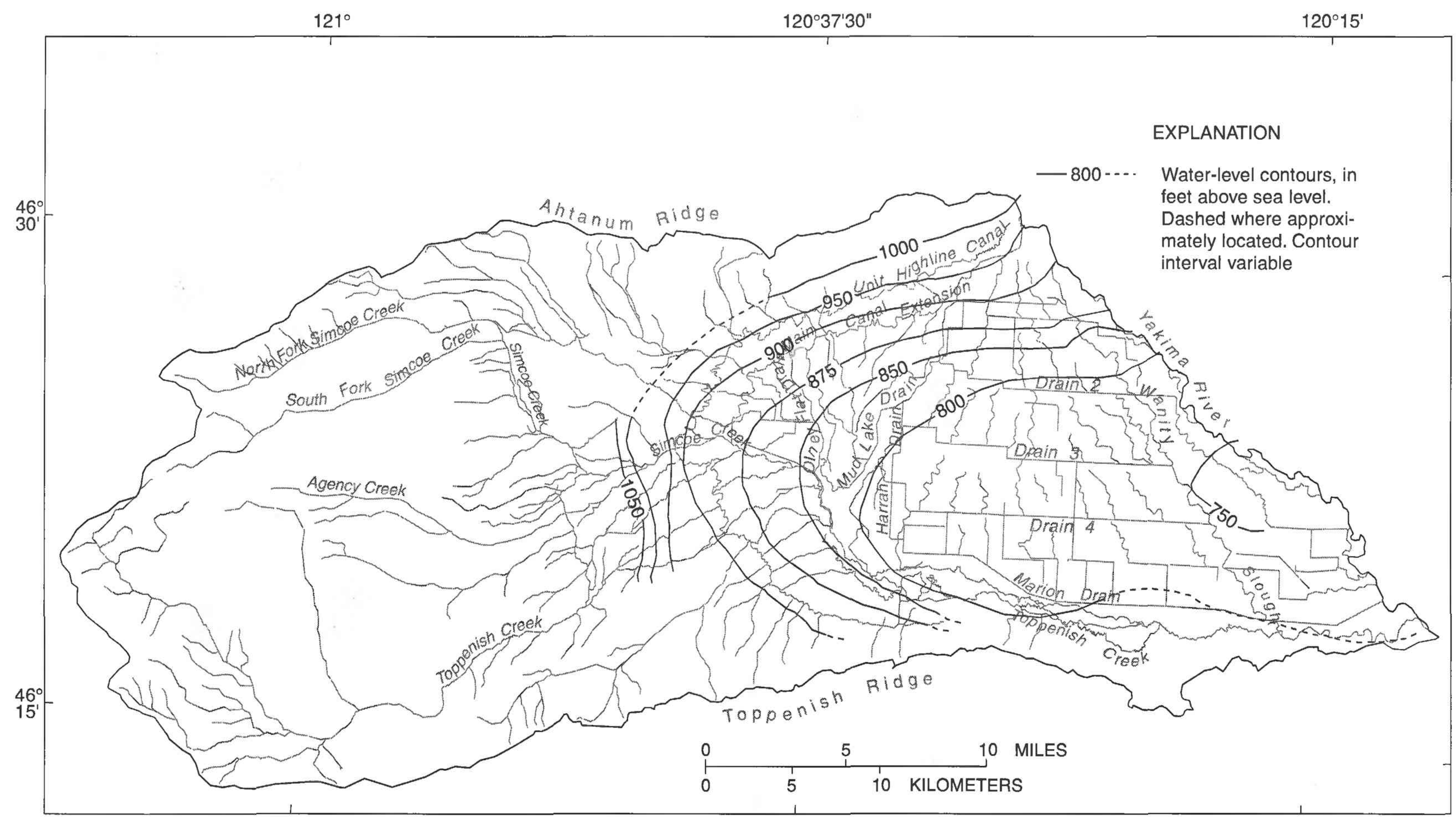

Figure 4. Average July and August water-level contours in the water-table aquifer in the young and old valley fill aquifers, March 1972 (U.S. Geological Survey, 1975).

Sampling

All samples for the seasonal and intensive phases were collected from a point prior to any water treatment such as chlorination, fluoridation, or softening. However, in most cases, it was not possible to obtain the sample before the water had gone through a pressure tank. Sample water was obtained from a faucet located as close to the wellhead as possible. For samples collected during the seasonal sampling phase, the faucet was connected by garden hose directly to a flow chamber, where instrument probes monitored temperature, pH, and dissolved oxygen. The specific conductance of the water was measured separately. If the probe-measured dissolved-oxygen concentration was less than 0.2 mg/L, two water samples were collected from the faucet and duplicate Winkler titrations were performed on them to confirm the low dissolved oxygen reading. About 10 percent of the samples collected during each sampling trip were also analyzed for total ammonia and total organic nitrogen. In addition, total ammonia and total organic nitrogen concentrations were determined for samples of water in which the dissolved oxygen concentration was less than 2.0 mg/L.

During the seasonal phase of the project, samples from 20 wells were analyzed for nitrate concentrations and concentrations of fecal-coliform, fecal-streptococcal, and *E. coli* bacteria (the same constituents analyzed for in the synoptic phase). Bacterial concentrations were determined using membrane filtration techniques with appropriate growth media and test solutions (Dufour and others, 1981; Britton and Greeson, 1988).

For samples collected for the intensive sampling phase, the faucet was connected with nylon tubing to a stainless-steel, flow-directing manifold in the field vehicle. A schematic diagram of the system is shown in figure 5. Valves in the manifold directed water to a flow chamber, a raw-water line, and a filtering apparatus. Instrument probes in the flow chamber monitored temperature, specific conductance, pH, and dissolved-oxygen concentrations. Samples were collected after readings for these constituents were steady for at least 10 minutes (Wood, 1981). Samples were processed and preserved, if needed, on-site in accordance with procedures listed in Watterson and Kashuba (1993). Nutrient and pesticide samples were shipped on ice to the National Water Quality Laboratory, Arvada, Colo.

Samples collected during the intensive phase were analyzed for major ions, nutrients, trace elements, and pesticides. The pesticides that were analyzed for during this phase of the project are listed in table 2. Analytical procedures were not available for some of the pesticides used in the basin; these pesticides are also listed in table 2. The selection of specific pesticides for analysis was based on a Water Resources Planning Program listing of pesticides used in the basin (Jannine Jennings, Yakama Indian Nation, written commun., 1989) and from a survey conducted by the U.S. Environmental Protection Agency (Sacha and others, 1987).

QUALITY ASSURANCE

Field measurements of temperature, specific conductance, pH, and dissolved oxygen were obtained using instruments that were calibrated at least once a day. Duplicate samples of ground water were collected at every tenth well visited during all sampling phases of the project. The same suite of analyses (field and laboratory) was performed on both the regular and duplicate samples. Samples of deionized water (field blanks) were submitted at the same frequency as duplicates. The preparation of the field blank varied, depending on the sampling phase of the project. During the synoptic and seasonal sampling phases, sample bottles were filled from stock containers of deionized water. During the intensive sampling phase, deionized water was pumped through the manifold system and the filtering apparatus to prepare the field blanks.

A summary and discussion of the quality-assurance data for the synoptic phase of the study are presented in a report by Payne and Sumioka (1994).

Average concentration differences between duplicate samples collected during the seasonal and intensive sampling phases of the project were less than 10 percent (table 3). Differences in percentage were not determined for a constituent detected in one of a pair of duplicate samples but not detected in the other. In cases such as these, the presence or absence of the constituent at a particular location could not be determined conclusively.

Some inorganic constituents were detected in samples of deionized water submitted for analysis as blanks (table 4), but the concentrations were only slightly greater than the detection limits for the analytical method used and were one to two orders of magnitude less than the respective concentrations in the ground-water samples. No organic compounds were detected in the blank samples.

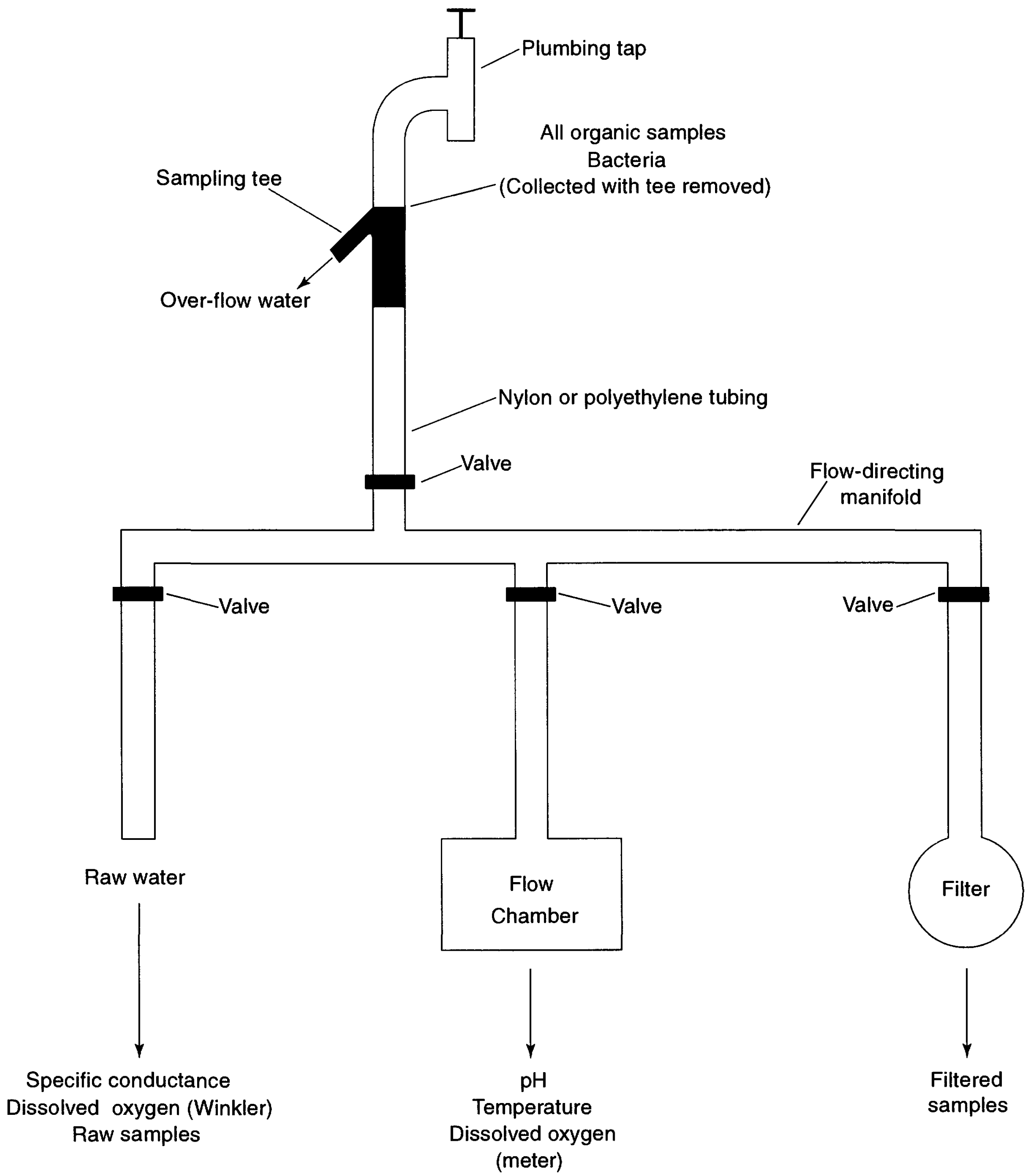

Figure 5. Ground-water sampling system with flow-directing manifold.

Table 2.--*Pesticides used in the Toppenish Creek Basin, Washington, (Jannine Jennings, Yakama Indian Nation, written commun., 1989)*
[pt, pint; qt, quart; gal, gallon; lb, pound; n.r., no rate reported; --, not included in Yakama Indian Nation Survey]

Brand name	Common name	Use	Annual application rate	Crops	Analyzed for in this study
Aatrex	atrazine	herbicide	0.5-1 qt/acre, asparagus 1 lb/acre, corn	asparagus, corn	Yes
Amiben[1]	chloramben	herbicide	--	pumpkins	No
Banvel	dicamba	herbicide	1 pt/acre	beans	Yes
Basagran[1]	bentazon	herbicide	--	corn, mint, peas	No
Bayleton	triadimefon	fungicide	n.r.	apples	No
Benlate	benomyl	fungicide	2 lb/acre	beans	No
Chem-Hoe[1]	propham	herbicide	--	alfalfa	Yes
Cygon	dimethoate	acaricide	1 pt/acre	beans	No
Dacthal	DCPA	herbicide	9 lb/acre	onions	No
2, 4-D	2, 4-D	herbicide	1 pt/acre	wheat	Yes
Diazinon 50W	diazinon	insecticide	2 lb/acre	hops	Yes
Dinitro[1]	dinoseb	herbicide-desiccant	--	cucumbers, beans, potatoes	No
Diquat	diquat	herbicide-desiccant	n.r.	alfalfa	No
Di-Syston[1]	disulfoton	insecticide	--	asparagus, lettuce	Yes
Dual[1]	metolachlor	herbicide	--	beans, corn	Yes
Endosulfan	endosulfan	acaricide	n.r.	peaches	Yes
Eptam	EPTC	herbicide	0.5 gal/acre	beans	No
Furadan[1]	carbofuran	insecticide	--	alfalfa, corn	Yes
Goal	oxyfluorfen	herbicide	1 pt/acre	onions, beans	No
Guthion 2S	azinphos-methyl	insecticide	2 lb/80 gal water	apples	Yes
Karmex[1]	diuron	herbicide	--	apples	No
Kelthane	dicofol	acaricide	1.5-3 qt/acre	hops	No
Kerb[1]	pronamide	herbicide	--	alfalfa	No
Kocide	cupric hydroxide	fungicide	n.r.	peaches	No
Lannate	methomyl	insecticide	2 lb/acre	sweet corn	Yes
Lasso	alachlor	herbicide	1 qt/acre	corn	Yes
Lexone	metribuzin	herbicide	0.5 lb/acre	alfalfa	Yes
Lorsban	chlorpyrifos	insecticide	10 lb/acre	onions	Yes
MonDak	mix of dicamba and MCPA	herbicide	1 pt/acre	wheat	No
Niran	parathion	acaricide	2 qt/acre 1.5 pt/100 gal	hops pears	Yes
Pounce	permethrin	insecticide	3.5 lb/acre	corn	No
Princep	simazine	herbicide	n.r.	apples	Yes
Pydrin	fenvalerate	insecticide	n.r.	cabbage	No
Roundup	glyphosate	herbicide	1 qt/acre	wheat	No
Rovral	iprodione	fungicide	2-10 lb/acre	cherries	No
Sinbar	terbacil	herbicide	1-2 lb/acre	mint	Yes
Sonalan	ethalfluralin	herbicide	2 pt/ac for beans n.r. for corn	beans, corn	No
Sutan[1]	butylate	herbicide		corn	Yes
Temik[1]	aldicarb	acaricide-nematocide	--	potatoes	Yes
Thiolup	wettable sulfur	fungicide-acaricide	7 lb/acre	apples	No
Tordon[1]	picloram	herbicide	--	grass, hay	Yes
Vitavax[1]	carboxin	fungicide	--	barley	Yes
Vydate	oxamyl	insecticide	1-2 pt/acre	apples	Yes

[1] From Sacha and others, 1987

Table 3.--*Average difference between constituent concentration in duplicate pairs of samples collected during the seasonal and intensive sampling phases*

Constituent/ characteristic	Number of duplicate pairs	Average difference, in percent	Number of pairs exceeding difference criteria[a]
Hardness	6	1.2	0
Calcium	6	2.0	0
Magnesium	6	0.2	0
Sodium	6	4.0	0
Potassium	6	4.2	0
Sulfate	6	1.2	0
Chloride	6	3.2	0
Fluoride	6	--[b]	--
Silica	6	1.0	0
Dissolved solids	6	4.0	0
Nitrate	23	1.3	0
Ammonia	10	--[b]	--
Ammonia-plus- organic nitrogen	9	--[b]	--
Phosphorus	6	2.2	1
Iron	6	--[b]	--
Manganese	6	--[b]	--
Aluminum	6	--[b]	--
Barium	6	3.2	0
Cobalt	6	--[b]	--
Lithium	6	--[b]	--
Mercury	4	--[b]	--
Molybdenum	6	--[b]	--
Nickel	6	--[b]	--
Selenium	6	--[b]	--
Silver	6	--[b]	--
Strontium	6	0.8	0
Vanadium	6	6.8	0
Disulfoton	6	--[b]	--
Diazinon	6	--[b]	--

[a] Difference criteria are 10 percent for major ions and dissolved solids, and 20 percent for trace elements and pesticides.

[b] Percentage difference was not computed because the concentration of the constituent in one sample of a pair was below the detection level of the analytical method.

Table 4.--*Constituent concentrations determined in blank samples for the intensive sampling phase*

[mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than]

Constituent	Number of blanks	Detection limit	Maximum blank concentration	Median sample concentration	Number of blanks equal to or exceeding detection limit
Calcium (mg/L)	6	0.02	0.39	36.0	6
Magnesium (mg/L)	6	0.01	0.14	13.0	4
Sodium (mg/L)	6	0.2	0.2	13.0	1
Potassium (mg/L)	6	0.1	0.1	3.4	1
Sulfate (mg/L)	6	0.1	0.3	14.0	4
Chloride (mg/L)	6	0.1	0.4	6.2	1
Fluoride (mg/L)	6	0.1	<0.1	0.2	0
Silica (mg/L)	6	0.01	0.33	36.0	6
Dissolved solids (mg/L)	6	1.0	7.0	222	3
Nitrate (mg/L)	6	0.05	<0.05	4.4	0
Ammonia (mg/L)	6	0.01	0.02	<0.01	3
Ammonia-plus-organic nitrogen (mg/L)	6	0.2	<0.2	<0.2	0
Phosphorus (mg/L)	6	0.01	<0.01	0.06	0
Iron (µg/L)	6	3.0	4.0	<3.0	1
Manganese (µg/L)	6	1.0	<1.0	<1.0	0
Aluminum (µg/L)	6	10.0	<10.0	<10.0	0
Barium (µg/L)	6	2.0	<2.0	10.0	0
Cobalt (µg/L)	6	3.0	<3.0	<3.0	0
Lithium (µg/L)	6	4.0	<4.0	<4.0	0
Mercury (µg/L)	6	0.1	<0.1	<0.1	0
Molybdenum (µg/L)	6	10.0	<10.0	<10.0	0
Nickel (µg/L)	6	1.0	<1.0	<1.0	0
Selenium (µg/L)	6	1.0	<1.0	<1.0	0
Silver (µg/L)	6	1.0	<1.0	<1.0	0
Strontium (µg/L)	6	1.0	2.0	150	3
Vanadium (µg/L)	6	6.0	<6.0	7.0	0
Pesticides (µg/L)[a]	6	[b]	[b]	[b]	0

[a] No pesticides were detected in blank samples.

[b] Detection limits vary from 0.01 to 0.5 µg/L, depending upon the pesticide. In all cases the maximum blank concentrations and the median sample concentrations were less than the detection limit.

Table 5.--*U.S. Environmental Protection Agency primary and secondary drinking water standards (U.S. Environmental Protection Agency, 1994)*

[All values in micrograms per liter except where noted; mg/L, milligrams per liter]

Constituent	Maximum contaminant level	
PRIMARY		
Inorganic		
Arsenic	50	
Barium	2	mg/L
Beryllium	4	
Cadmium	5	
Fluoride	4	mg/L
Mercury	2	
Nickel	100	
Nitrite + Nitrate	10	mg/L
Selenium	50	
Organic		
2,4-D	70	
Atrazine	3	
Alachlor	2	
Carbofuran	40	
Oxamyl	200	
Picloram	500	
Simazine	4	
SECONDARY		
Aluminum	50-200	
Chloride	250	mg/L
Copper	1	mg/L
Iron	300	
Manganese	50	
pH	6.5-8.5	
Silver	100	
Sulfate	250	mg/L
Total dissolved solids	500	mg/L
Zinc	5	

GROUND-WATER QUALITY

A review of the data collected during the three sampling phases of the project indicates that only the concentrations of nitrate and mercury in a few wells exceeded U.S. Environmental Protection Agency (USEPA, table 5) criteria for drinking water. Samples collected from 2 of 487 wells (11N/18E-10C01 and 11N/18E-27R01) during the synoptic sampling phase contained nitrate concentrations greater than the USEPA drinking water criterion of 10 mg/L (Payne and Sumioka, 1994; Appendix 1, this report). During the seasonal sampling phase, all samples (9) collected from well 11N/18E-10C01 (table 6) had nitrate concentrations greater than the drinking water criterion (table 5). At least one sample from four other wells (11N/18E-22D01, 11N/18E-27N01, 11N/18E-31A01, and 12N/19E-29G01) contained nitrate in concentrations at or greater than the drinking water criterion. (Well 11N/18E-27N01 was not included in the seasonal sampling phase because it is an irrigation well and is not pumped year around.) Samples collected from two wells (11N/18E-10C01 and 11N/18E-27N01, table 7) during the intensive sampling phase had nitrate concentrations greater than the criterion. A water sample from well 12N/19E-29G01 had a mercury concentration of 4 μg/L (micrograms per liter, table 8), which exceeded the USEPA criterion of 2 μg/L.

Secondary drinking water standards (table 5), non-enforceable criteria for constituents that affect the asthetic quality of drinking water, were exceeded in samples collected from 2 of 60 wells during the intensive sampling phase. Concentrations of dissolved solids and manganese (517 mg/L and 740 mg/L, respectively, table 7) in a sample from well 11N/18E-31A01 were greater than the criteria of 500 mg/L and 50 μg/L, respectively. Concentrations of total dissolved solids in two samples from 10N/18E-36A01 were 694 and 720 mg/L (table 7).

Agricultural Pesticides

A variety of pesticides is used in the basin to control weeds, insects, and spiders and mites. A survey conducted by the Yakama Indian Nation of farmers in the basin indicated that 30 pesticides were used by those farmers (Jannine Jennings, Yakama Indian Nation, written commun., 1989; table 1). An additional 12 pesticides were reported by the U.S. Environmental Protection Agency (Sacha and others, 1987) as being used in the basin but were not included in the Yakama Indian Nation survey (table 1).

Table 6.--*Field measurements and concentrations of nitrogen compounds and bacteria in ground-water samples collected during the seasonal sampling program*

[µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; cols./100 ml, colonies per 100 milliliters; --, no data; <, less than; K, non-ideal count]

Local well number	Date	Specific conductance (µS/cm)	pH water, whole field (standard units)	Temperature water (°C)	Oxygen, dissolved (mg/L)	Nitrogen, NO_2+NO_3, total (mg/L as N)
10N/18E-02Q01	01-31-91	346	7.2	13.5	6.4	5.7
	03-20-91	331	7.2	14.0	7.2	5.4
	05-15-91	340	6.7	14.0	7.9	5.8
	07-24-91	320	6.9	14.5	3.8	1.5
	09-24-91	321	7.2	14.5	6.9	5.5
	11-21-91	333	7.2	14.5	--	5.3
	01-16-92	337	7.1	14.0	6.3	5.3
	03-11-92	318	7.3	14.0	6.8	5.3
	04-30-92	331	7.2	14.0	6.7	4.9
10N/18E-02R01	02-02-91	348	7.4	14.5	7.6	4.4
	03-19-91	340	7.5	14.0	9.6	4.0
	05-14-91	347	7.3	14.5	6.9	4.9
	07-23-91	345	7.4	18.0	7.4	4.9
	09-24-91	346	7.5	15.0	7.0	5.1
	11-21-91	346	7.5	14.5	7.3	5.0
	01-16-92	345	7.4	14.5	7.1	5.0
	03-11-92	331	7.5	14.5	6.6	5.1
	04-30-92	336	7.5	15.0	6.6	4.9
10N/18E-04Q01	02-02-91	555	7.4	13.0	3.2	4.9
	03-19-91	545	7.4	13.5	5.5	4.0
	05-15-91	561	7.0	14.0	4.3	5.1
	07-24-91	527	7.4	14.5	4.3	5.7
	09-24-91	574	7.4	14.0	4.0	5.7
	11-22-91	554	7.3	14.0	4.3	5.0
	01-17-92	545	7.4	14.0	3.9	4.4
	03-11-92	516	7.5	14.0	3.9	4.6
	04-30-92	520	7.4	14.0	3.7	4.1
10N/18E-15A01	01-31-91	412	7.2	11.5	4.2	5.9
	03-19-91	408	7.4	12.0	4.5	6.2
	05-15-91	398	7.1	13.5	6.1	6.6
	07-23-91	386	7.3	--	6.2	6.0
	09-25-91	392	7.2	14.0	5.3	5.8
	11-22-91	391	7.2	13.0	4.9	5.8
	01-16-92	395	7.2	13.0	4.9	6.0
	04-30-92	387	7.2	13.5	5.4	6.3

Table 6.--*Field measurements and concentrations of nitrogen compounds and bacteria in ground-water samples collected during the seasonal sampling program--Continued*

Local well number	Date	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Coliform, fecal (cols./ 100 ml)	Streptococci, fecal (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
10N/18E-02Q01	01-31-91	0.03	0.5	<1	<1	<1
	03-20-91	0.01	<0.2	<1	<1	<1
	05-15-91	--	--	<1	<1	<1
	07-24-91	--	--	<1	<1	<1
	09-24-91	--	--	<1	<1	<1
	11-21-91	--	--	<1	<1	<1
	01-16-92	--	--	<1	<1	<1
	03-11-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	<1	<1
10N/18E-02R01	02-02-91	<0.01	--	<1	<1	<1
	03-19-91	--	--	<1	<1	<1
	05-14-91	--	--	<1	<1	<1
	07-23-91	--	--	<1	<1	<1
	09-24-91	--	--	<1	<1	<1
	11-21-91	--	--	<1	<1	<1
	01-16-92	--	--	<1	<1	<1
	03-11-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	<1	<1
10N/18E-04Q01	02-02-91	<0.01	--	<1	<1	<1
	03-19-91	--	--	<1	<1	<1
	05-15-91	--	--	<1	<1	<1
	07-24-91	--	--	<1	<1	<1
	09-24-91	--	--	<1	<1	<1
	11-22-91	--	--	<1	<1	<1
	01-17-92	--	--	<1	1	<1
	03-11-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	<1	<1
10N/18E-15A01	01-31-91	--	--	<1	<1	<1
	03-19-91	0.01	0.3	<1	<1	<1
	05-15-91	--	--	<1	<1	<1
	07-23-91	--	--	<1	<1	<1
	09-25-91	--	--	<1	<1	<1
	11-22-91	--	--	<1	<1	<1
	01-16-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	<1	<1

Table 6.--*Field measurements and concentrations of nitrogen compounds and bacteria in ground-water samples collected during the seasonal sampling program--Continued*

Local well number	Date	Specific conductance (μS/cm)	pH water, whole field (standard units)	Temperature water (°C)	Oxygen, dissolved (mg/L)	Nitrogen, NO_2+NO_3, total (mg/L as N)
10N/18E-15H01	02-02-91	407	7.3	11.5	3.2	5.5
	03-19-91	415	7.4	13.0	3.8	5.8
	05-15-91	421	7.0	14.0	5.0	6.5
	07-24-91	414	7.1	--	4.8	5.9
	09-25-91	415	7.3	14.0	4.3	5.8
	11-22-91	404	7.3	13.5	4.2	5.8
	01-16-92	410	7.3	13.0	4.2	5.6
	03-12-92	394	7.4	13.0	4.1	5.6
	04-30-92	404	7.4	14.0	4.3	6.1
10N/18E-36A01	02-02-91	1,020	7.4	15.5	7.5	6.1
	03-19-91	1,070	7.5	15.0	5.8	7.1
	05-14-91	1,040	7.3	15.5	6.0	5.6
	07-25-91	937	7.5	16.0	5.6	7.4
	09-24-91	1,100	7.5	16.0	5.8	7.3
	11-22-91	1,040	7.4	15.5	7.5	6.4
	01-17-92	1,100	7.4	15.0	6.1	6.7
	03-12-92	920	7.5	15.5	5.6	6.9
	04-29-92	950	7.4	14.0	6.0	6.2
10N/19E-25A01	02-01-91	357	7.4	10.0	--	5.0
	03-22-91	352	7.5	10.5	--	4.6
	05-15-91	357	7.3	13.5	--	5.0
	07-24-91	350	7.4	15.5	--	4.2
	09-24-91	375	7.4	14.5	--	3.9
	11-22-91	369	7.4	13.0	3.1	4.0
	01-15-92	369	7.5	11.0	--	4.3
	03-12-92	340	7.5	12.5	3.8	4.5
	04-30-92	350	7.5	13.0	4.4	4.9
10N/19E-25H02	02-01-91	383	7.3	13.5	2.4	5.3
	03-19-91	371	7.4	14.0	3.2	4.3
	05-14-91	383	7.2	14.0	2.2	5.3
	07-23-91	348	7.4	15.0	2.5	5.0
	09-24-91	378	7.5	15.5	2.2	4.7
	11-21-91	373	7.4	16.5	1.3	4.4
	01-16-92	373	7.4	14.0	1.3	4.2
	03-12-92	343	7.5	16.0	1.8	4.3
	04-29-92	357	7.4	14.0	2.0	4.6

Table 6.--*Field measurements and concentrations of nitrogen compounds and bacteria in ground-water samples collected during the seasonal sampling program--Continued*

Local well number	Date	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Coliform, fecal (cols./ 100 ml)	Streptococci, fecal (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
10N/18E-15H01	02-02-91	<0.01	--	<1	<1	<1
	03-19-91	<0.01	0.2	<1	<1	<1
	05-15-91	--	--	<1	<1	<1
	07-24-91	--	--	<1	<1	<1
	09-25-91	--	--	<1	<1	<1
	11-22-91	--	--	<1	<1	<1
	01-16-92	--	--	<1	<1	<1
	03-12-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	<1	<1
10N/18E-36A01	02-02-91	<0.01	--	<1	<1	<1
	03-19-91	0.03	0.7	<1	<1	<1
	05-14-91	--	--	<1	<1	<1
	07-25-91	--	--	<1	<1	<1
	09-24-91	--	--	<1	<1	<1
	11-22-91	--	--	<1	1	<1
	01-17-92	--	--	<1	1	<1
	03-12-92	--	--	<1	<1	<1
	04-29-92	--	--	<1	<1	<1
10N/19E-25A01	02-01-91	<0.01	--	<1	<1	<1
	03-22-91	--	--	<1	<1	<1
	05-15-91	--	--	<1	<1	<1
	07-24-91	--	--	<1	<1	<1
	09-24-91	--	--	<1	<1	<1
	11-22-91	--	--	<1	<1	<1
	01-15-92	--	--	<1	<1	<1
	03-12-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	K1	<1
10N/19E-25H02	02-01-91	<0.01	--	<1	<1	<1
	03-19-91	--	--	<1	<1	<1
	05-14-91	<0.01	0.2	<1	<1	<1
	07-23-91	--	--	<1	<1	<1
	09-24-91	<0.01	0.5	<1	<1	<1
	11-21-91	--	--	<1	<1	<1
	01-16-92	--	--	<1	<1	<1
	03-12-92	--	--	<1	<1	<1
	04-29-92	--	--	<1	<1	<1

Table 6.--*Field measurements and concentrations of nitrogen compounds and bacteria in ground-water samples collected during the seasonal sampling program--Continued*

Local well number	Date	Specific conductance (μS/cm)	pH water, whole field (standard units)	Temperature water (°C)	Oxygen, dissolved (mg/L)	Nitrogen, NO_2+NO_3, total (mg/L as N)
10N/19E-25H03	02-02-91	398	7.4	11.5	1.3	5.3
	03-21-91	397	7.4	13.0	1.0	5.3
	05-14-91	404	7.3	14.0	1.2	5.8
	07-23-91	369	7.4	14.5	2.0	5.0
	09-24-91	406	7.4	--	1.8	4.5
	11-21-91	397	7.4	12.5	1.2	4.8
	01-16-92	400	7.3	11.0	1.5	5.0
	03-12-92	366	7.4	12.0	1.1	4.8
	04-29-92	387	7.3	13.5	1.4	5.0
10N/20E-21G02	02-01-91	343	7.0	13.0	3.5	5.4
	03-19-91	338	7.1	13.0	3.2	5.2
	05-14-91	342	7.0	14.0	3.2	5.5
	07-23-91	320	7.1	14.0	3.0	5.4
	09-25-91	343	7.1	14.0	3.0	5.3
	11-22-91	344	7.1	10.5	3.3	5.2
	01-16-92	343	7.0	14.0	3.3	5.2
	03-11-92	314	7.1	13.0	3.1	5.0
	04-30-92	328	7.0	14.5	3.2	5.1
10N/20E-28H02	02-01-91	352	7.2	13.5	4.0	5.4
	03-19-91	347	7.1	14.0	3.2	4.8
	05-14-91	349	7.0	14.5	3.7	7.4
	07-23-91	331	7.0	14.0	2.5	5.6
	09-24-91	350	7.2	14.5	3.8	5.7
	11-22-91	352	7.1	14.0	3.3	5.9
	01-16-92	356	7.0	13.5	1.5	5.6
	03-11-92	325	7.2	14.0	3.0	6.0
	04-30-92	341	7.1	14.5	1.3	5.3
10N/20E-29E01	02-01-91	379	7.2	14.0	2.9	5.0
	03-21-91	368	7.3	13.5	2.5	4.8
	05-14-91	374	7.0	14.5	3.1	5.3
	07-24-91	349	7.2	16.0	2.6	5.3
	09-24-91	374	7.2	--	3.2	5.2
	11-21-91	372	7.2	12.5	2.2	5.0
	01-15-92	378	7.3	11.5	3.1	5.2
	03-11-92	345	7.3	12.0	2.1	4.8

Table 6.--*Field measurements and concentrations of nitrogen compounds and bacteria in ground-water samples collected during the seasonal sampling program--Continued*

Local well number	Date	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Coliform, fecal (cols./ 100 ml)	Streptococci, fecal (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
10N/19E-25H03	02-02-91	<0.01	0.5	<1	<1	<1
	03-21-91	0.02	0.2	<1	<1	<1
	05-14-91	<0.01	0.5	<1	<1	<1
	07-23-91	<0.01	0.3	<1	<1	<1
	09-24-91	<0.01	0.3	<1	<1	<1
	11-21-91	--	--	--	--	--
	01-16-91	--	--	<1	<1	<1
	03-12-92	--	--	<1	<1	<1
	04-29-92	--	--	--	--	--
10N/20E-21G02	02-01-91	0.01	--	<1	<1	<1
	03-19-91	0.02	<0.2	<1	<1	<1
	05-14-91	--	--	<1	<1	<1
	07-23-91	--	--	<1	<1	<1
	09-25-91	<0.01	0.5	<1	<1	<1
	11-22-91	--	--	<1	<1	<1
	01-16-92	--	--	<1	<1	<1
	03-11-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	<1	<1
10N/20E-28H02	02-01-91	<0.01	--	<1	<1	<1
	03-19-91	0.01	0.2	<1	22	<1
	05-14-91	--	--	<1	<1	<1
	07-23-91	--	--	<1	<1	<1
	09-24-91	--	--	<1	<1	<1
	11-22-91	--	--	<1	<1	<1
	01-16-92	--	--	<1	<1	<1
	03-11-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	<1	<1
10N/20E-29E01	02-01-91	<0.01	--	<1	K1	<1
	03-21-91	0.02	0.3	<1	<1	<1
	05-14-91	--	--	<1	<1	<1
	07-24-91	--	--	<1	<1	<1
	09-24-91	--	--	<1	<1	<1
	11-21-91	--	--	<1	<1	<1
	01-15-92	--	--	<1	<1	<1
	03-11-92	--	--	<1	<1	<1

Table 6.--*Field measurements and concentrations of nitrogen compounds and bacteria in ground-water samples collected during the seasonal sampling program--Continued*

Local well number	Date	Specific conductance (μS/cm)	pH water, whole field (standard units)	Temperature water (°C)	Oxygen, dissolved (mg/L)	Nitrogen, NO_2+NO_3, total (mg/L as N)
11N/18E-10C01	01-31-91	545	7.6	13.5	9.4	29
	03-21-91	570	7.6	14.5	9.6	27
	05-15-91	530	7.5	15.0	9.0	29
	07-23-91	501	7.6	16.0	8.4	30
	09-24-91	564	7.6	16.0	9.2	30
	11-23-91	559	7.7	14.5	--	28
	01-17-92	557	7.7	12.5	--	27
	03-12-92	538	7.8	13.0	8.2	30
	04-29-92	545	7.7	14.5	7.7	29
11N/18E-22D01	01-30-91	611	7.6	12.5	4.4	8.0
	03-20-91	676	7.6	12.0	4.2	9.0
	05-14-91	700	7.5	13.5	4.4	11
	07-24-91	717	7.3	14.0	3.7	9.6
	09-25-91	672	7.6	15.0	4.4	7.5
	11-20-91	623	7.6	13.5	5.5	5.5
	01-17-92	612	7.6	13.0	5.3	6.6
	03-12-92	607	7.6	15.0	5.3	8.1
	04-29-92	655	7.9	15.0	4.7	10
11N/18E-22R02	01-31-91	370	7.2	13.0	--	8.2
	03-20-91	360	7.1	13.5	6.3	7.4
	05-14-91	315	7.1	13.5	7.6	5.3
	07-24-91	317	7.0	14.0	3.7	4.4
	09-25-91	300	7.2	16.5	5.5	3.5
	11-20-91	340	7.1	15.5	6.0	5.3
	01-17-92	379	7.0	11.0	5.1	7.3
	03-12-92	356	7.2	13.5	6.7	6.6
	04-29-92	352	7.4	14.0	6.6	6.3
11N/18E-27N01	01-31-91	523	7.4	11.5	5.4	11
	03-20-91	544	7.4	13.5	5.7	12.0
	05-14-91	502	7.4	14.0	5.4	10
	07-24-91	496	7.4	14.0	3.7	9.3
	09-25-91	490	7.4	14.5	6.1	8.5
	11-21-91	488	7.4	14.0	7.0	8.5
	01-15-92	502	7.4	12.5	6.0	8.9
	03-12-92	491	7.4	13.5	5.8	9.5
	04-30-92	491	7.4	14.0	5.3	9.9

Table 6.--*Field measurements and concentrations of nitrogen compounds and bacteria in ground-water samples collected during the seasonal sampling program--Continued*

Local well number	Date	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Coliform, fecal (cols./ 100 ml)	Streptococci, fecal (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
11N/18E-10C01	01-31-91	0.01	--	<1	<1	<1
	03-21-91	<0.01	0.5	<1	<1	<1
	05-15-91	--	--	<1	<1	<1
	07-23-91	--	--	<1	<1	<1
	09-24-91	--	--	<1	<1	<1
	11-23-91	--	--	<1	<1	<1
	01-17-92	--	--	<1	<1	<1
	03-12-92	--	--	<1	<1	<1
	04-29-92	--	--	<1	<1	<1
11N/18E-22D01	01-30-91	<0.01	--	<1	<1	<1
	03-20-91	0.02	0.4	<1	<1	<1
	05-14-91	--	--	<1	<1	<1
	07-24-91	--	--	<1	<1	<1
	09-25-91	--	--	<1	<1	<1
	11-20-91	--	--	<1	<1	<1
	01-17-92	--	--	<1	<1	<1
	03-12-92	--	--	<1	<1	<1
	04-29-92	--	--	<1	<1	<1
11N/18E-22R02	01-31-91	<0.01	--	<1	<1	<1
	03-20-91	0.01	0.4	<1	<1	<1
	05-14-91	--	--	4	<1	3
	07-24-91	--	--	<1	<1	<1
	09-25-91	--	--	<1	<1	<1
	11-20-91	--	--	<1	<1	<1
	01-17-92	--	--	<1	<1	<1
	03-12-92	--	--	<1	<1	<1
	04-29-92	--	--	<1	<1	<1
11N/18E-27N01	01-31-91	<0.01	--	<1	<1	<1
	03-20-91	0.01	0.5	<1	<1	<1
	05-14-91	--	--	<1	<1	<1
	07-24-91	--	--	<1	<1	<1
	09-25-91	--	--	<1	<1	<1
	11-21-91	--	--	<1	<1	<1
	01-15-92	--	--	<1	<1	<1
	03-12-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	<1	<1

Table 6.--*Field measurements and concentrations of nitrogen compounds and bacteria in ground-water samples collected during the seasonal sampling program--Continued*

Local well number	Date	Specific conductance (µS/cm)	pH water, whole field (standard units)	Temperature water (°C)	Oxygen, dissolved (mg/L)	Nitrogen, NO_2+NO_3, total (mg/L as N)
11N/18E-27R02	01-31-91	388	7.3	12.0	5.7	6.3
	03-20-91	390	7.2	13.5	6.1	6.4
	05-14-91	341	7.3	13.5	6.8	5.1
	07-25-91	314	7.2	14.5	6.8	4.1
	09-25-91	338	7.3	14.5	6.6	4.6
	11-21-91	368	7.2	14.5	7.1	5.5
	01-16-92	386	7.2	14.0	6.7	6.0
	03-12-92	373	7.3	14.0	7.2	5.8
	04-30-92	375	7.3	14.0	6.7	5.9
11N/18E-31A01	02-01-91	806	7.4	11.5	0.2	8.0
	03-19-91	779	7.3	--	0.1	6.5
	05-15-91	718	7.3	13.5	0.2	6.0
	07-24-91	791	7.0	13.5	0.2	7.3
	09-25-91	856	7.2	14.0	0.3	9.5
	11-21-91	878	7.2	13.5	--	9.9
	01-16-92	868	7.2	13.0	0.3	10
	03-12-92	791	7.3	13.5	0.4	9.8
	04-30-92	720	7.3	14.0	0.8	7.5
11N/19E-29N01	02-01-91	282	6.9	13.5	6.2	3.5
	03-19-91	280	6.9	14.0	6.1	3.1
	05-15-91	271	6.7	14.0	3.6	3.2
	07-23-91	259	7.0	13.5	7.6	4.4
	09-25-91	270	6.9	14.5	6.6	3.9
	11-23-91	268	7.0	14.0	6.3	3.1
	01-16-92	282	6.8	13.5	6.7	2.9
	03-12-92	262	6.9	14.0	5.5	2.8
	04-30-92	272	6.9	13.5	5.5	2.8
12N/19E-29G01	02-01-91	577	7.8	11.0	0.7	<0.1
	03-21-91	641	7.7	--	2.1	<0.05
	05-16-91	855	7.8	--	7.1	16
	07-24-91	702	7.4	17.0	3.8	10
	09-25-91	576	7.5	16.5	2.8	0.83
	11-21-91	547	7.6	--	--	<0.05
	01-16-92	538	7.8	10.5	1.3	<0.05
	03-12-92	459	7.9	13.0	1.4	<0.05
	04-30-92	559	7.6	14.5	1.1	<0.05

Table 6.--*Field measurements and concentrations of nitrogen compounds and bacteria in ground-water samples collected during the seasonal sampling program--Continued*

Local well number	Date	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Coliform, fecal (cols./ 100 ml)	Streptococci, fecal (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
11N/18E-27R02	01-31-91	<0.01	--	<1	<1	<1
	03-20-91	0.03	0.4	<1	<1	<1
	05-14-91	--	--	<1	<1	<1
	07-25-91	--	--	<1	<1	<1
	09-25-91	--	--	<1	<1	<1
	11-21-91	--	--	<1	<1	<1
	01-16-92	--	--	<1	<1	<1
	03-12-92	--	--	<1	<1	<1
	04-3^0-92	--	--	<1	K1	<1
11N/18E-31A01	02-01-91	<0.01	0.6	<1	<1	<1
	03-19-91	0.01	0.3	<1	<1	<1
	05-15-91	<0.01	0.3	<1	<1	<1
	07-24-91	0.02	0.5	<1	<1	<1
	09-25-91	<0.01	0.5	<1	<1	<1
	11-21-91	--	--	<1	<1	<1
	01-16-92	--	--	<1	1	<1
	03-12-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	<1	<1
11N/19E-29N01	02-01-91	0.01	--	<1	<1	<1
	03-19-91	0.01	<0.2	<1	<1	<1
	05-15-91	--	--	<1	<1	<1
	07-23-91	--	--	<1	<1	<1
	09-25-91	--	--	<1	<1	<1
	11-23-91	--	--	<1	<1	<1
	01-16-92	--	--	<1	<1	<1
	03-12-92	--	--	<1	<1	<1
	04-30-92	--	--	<1	<1	<1
12N/19E-29G01	02-01-91	0.01	<0.2	K5	K5	K3
	03-21-91	0.02	<0.2	<1	K2	<1
	05-16-91	--	--	<1	K38	<1
	07-24-91	--	--	<1	<1	<1
	09-25-91	--	--	<1	<1	<1
	11-21-91	--	--	<1	<1	<1
	01-16-92			<1	3	<1
	03-12-92			<1	<1	<1
	04-30-92			<1	K1	<1

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program*

[μS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; μg/L, micrograms per liter; --, no data]

Local well number	Date	Specific conductance (μS/cm)	pH water, whole field (standard units)	Temperature water (°C)	Oxygen, dissolved (mg/L)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)
10N/17E-29A01	08-06-92	354	7.4	16.5	6.8	150	29
10N/18E-02N01	08-06-92	367	7.4	14.0	6.0	140	35
10N/18E-02Q01	03-20-91	331	7.2	14.0	7.2	130	34
	08-05-92	340	7.1	16.5	5.3	140	34
	09-08-92	343	7.2	15.0	6.4	--	--
10N/18E-02R01	08-05-92	330	7.4	15.5	6.2	130	33
10N/18E-04C01	08-04-92	424	7.4	14.5	5.1	190	43
10N/18E-04Q01	08-04-92	496	7.3	14.5	3.8	200	45
10N/18E-06R04	08-04-92	584	7.0	15.5	2.0	260	58
10N/18E-15A01	03-19-91	408	7.4	12.0	4.5	170	41
	08-04-92	400	7.5	17.5	3.7	150	38
10N/18E-15H01	03-19-91	415	7.4	13.0	3.8	160	40
	08-04-92	400	7.3	14.0	4.3	160	41
10N/18E-36A01	03-19-91	1,070	7.5	15.0	5.8	540	130
	08-04-92	950	7.4	16.0	6.3	530	130
10N/19E-01J01	08-04-92	300	6.9	17.5	6.8	120	30
10N/19E-03A01	08-05-92	278	7.0	15.5	6.9	120	29
10N/19E-05L01	08-05-92	268	7.0	15.5	6.2	110	28
	09-08-92	256	7.0	15.5	4.1	--	--
10N/19E-07R01	08-04-92	325	7.6	17.5	5.2	130	35
10N/19E-08A01	08-04-92	275	7.1	17.0	7.5	110	29
10N/19E-21B01	08-05-92	281	7.6	17.5	5.0	120	33
10N/19E-21K01	08-04-92	310	7.3	20.5	5.3	130	33

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate (mg/L as HCO_3)	Carbonate (mg/L as CO_3)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L) as Cl)
10N/17E-29A01	08-06-92	20	11	1.9	174	0	143	15	8.5
10N/18E-02N01	08-06-92	13	16	4.1	184	0	151	15	6.4
10N/18E-02Q01	03-20-91	12	15	4.3	156	0	128	13	6.9
	08-05-92	13	14	4.1	158	0	130	15	6.2
	09-08-92	--	--	--	--	--	--	--	--
10N/18E-02R01	08-05-92	12	17	3.8	163	0	134	14	6.0
10N/18E-04C01	08-04-92	19	24	5.7	282	0	231	11	4.5
10N/18E-04Q01	08-04-92	22	37	6.3	277	0	227	22	10
10N/18E-06R04	08-04-92	29	31	5.3	295	0	242	65	16
10N/18E-15A01	03-19-91	16	21	4.3	203	0	167	21	8.8
	08-04-92	14	25	4.2	225	0	184	16	8.1
10N/18E-15H01	03-19-91	15	22	4.2	206	0	169	21	8.4
	08-04-92	15	21	4.2	205	0	168	21	9.5
10N/18E-36A01	03-19-91	52	25	3.6	404	0	331	130	66
	08-04-92	50	24	3.3	400	0	328	130	66
10N/19E-01J01	08-04-92	11	10	2.8	132	0	108	13	6.5
10N/19E-03A01	08-05-92	11	10	3.4	146	0	120	11	5.9
10N/19E-05L01	08-05-92	9.7	9	3.2	134	0	110	13	6.8
	09-08-92	--	--	--	--	--	--	--	--
10N/19E-07R01	08-04-92	10	15	3.4	170	0	139	10	6.0
10N/19E-08A01	08-04-92	9.6	9	3.2	137	0	112	8.9	5.8
10N/19E-21B01	08-05-92	9.7	13	3.0	157	0	129	9.7	4.8
10N/19E-21K01	08-04-92	11	13	3.1	153	0	125	10	6.4

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 180 oC, dissolved (mg/L)	Nitrogen, nitrite, total (mg/L as N)	Nitrogen, nitrite dissolved (mg/L as N)	Nitrogen, NO_2+ NO_3, total (mg/L as N)	Nitrogen, NO_2+ NO_3, dissolved (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)
10N/17E-29A01	08-06-92	0.3	59	242	<0.01	<0.01	4.4	4.4	0.01
10N/18E-02N01	08-06-92	0.2	42	244	<0.01	<0.01	5.0	5.0	0.02
10N/18E-02Q01	03-20-91	0.3	39	220	<0.01	<0.01	5.4	5.8	0.01
	08-05-92	0.2	40	220	<0.01	<0.01	5.5	5.4	<0.01
	09-08-92	--	--	--	--	--	--	--	--
10N/18E-02R01	08-05-92	0.2	44	220	<0.01	<0.01	4.7	4.8	<0.01
10N/18E-04C01	08-04-92	0.3	38	280	<0.01	<0.01	2.1	2.1	<0.01
10N/18E-04Q01	08-04-92	0.3	42	331	<0.01	<0.01	4.4	4.4	<0.01
10N/18E-06R04	08-04-92	0.10	47	409	<0.01	<0.01	3.0	2.9	<0.01
10N/18E-15A01	03-19-91	0.2	42	252	<0.01	0.01	6.2	6.1	0.01
	08-04-92	0.3	44	238	<0.01	<0.01	4.2	4.3	0.03
10N/18E-15H01	03-19-91	0.2	43	259	<0.01	0.01	5.8	6.0	<0.01
	08-04-92	0.3	42	270	<0.01	<0.01	5.6	5.9	0.02
10N/18E-36A01	03-19-91	0.2	58	694	<0.01	0.01	7.1	7.2	0.03
	08-04-92	0.2	55	720	<0.01	<0.01	6.8	6.8	0.03
10N/19E-01J01	08-04-92	0.1	36	216	<0.01	<0.01	5.1	5.2	0.02
10N/19E-03A01	08-05-92	0.2	35	190	<0.01	<0.01	3.4	3.5	0.02
10N/19E-05L01	08-05-92	0.2	34	173	<0.01	<0.01	3.1	3.1	0.03
	09-08-92	--	--	--	--	--	--	--	--
10N/19E-07R01	08-04-92	0.2	38	195	<0.01	<0.01	2.9	3.0	0.03
10N/19E-08A01	08-04-92	0.1	35	192	<0.01	<0.01	2.8	3.0	0.03
10N/19E-21B01	08-05-92	0.2	36	200	<0.01	<0.01	3.6	3.6	<0.01
10N/19E-21K01	08-04-92	0.2	37	193	<0.01	<0.01	3.9	3.9	0.02

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Phosphorus, total (mg/L as P)	Phosphorus, dissolved (mg/L as P)	Phosphorus ortho, total (mg/L as P)	Phosphorus ortho, dissolved (mg/L as P)	Iron, dissolved (µg/L as Fe)	Manganese, dissolved (µg/L as Mn)
10N/17E-29A01	08-06-92	0.02	<0.2	0.04	0.04	0.05	0.05	<3	<1
10N/18E-02N01	08-06-92	0.02	<0.2	0.09	0.09	0.09	0.09	<3	<1
10N/18E-02Q01	03-20-91	<0.01	<0.2	0.07	0.07	0.09	0.09	7	4
	08-05-92	<0.01	<0.2	0.07	0.07	0.07	0.07	5	1
	09-08-92	--	--	--	--	--	--	--	--
10N/18E-02R01	08-05-92	<0.01	<0.2	0.09	0.09	0.09	0.09	3	<1
10N/18E-04C01	08-04-92	<0.01	<0.2	0.25	0.28	0.24	0.24	<3	<1
10N/18E-04Q01	08-04-92	<0.01	<0.2	0.29	0.31	0.27	0.28	3	<1
10N/18E-06R04	08-04-92	<0.01	<0.2	0.21	0.22	0.18	0.20	<3	<1
10N/18E-15A01	03-19-91	<0.01	0.3	0.10	0.10	0.04	<0.01	8	<1
	08-04-92	0.03	<0.2	0.10	0.10	0.09	0.09	<3	<1
10N/18E-15H01	03-19-91	<0.01	0.2	0.11	0.11	0.07	<0.01	9	3
	08-04-92	0.03	<0.2	0.13	0.12	0.11	0.12	<3	<1
10N/18E-36A01	03-19-91	<0.01	0.7	0.06	0.06	0.03	<0.01	16	1
	08-04-92	0.03	<0.2	0.08	0.07	0.07	0.07	<3	<1
10N/19E-01J01	08-04-92	0.04	<0.2	0.04	0.04	0.04	0.04	<3	<1
10N/19E-03A01	08-05-92	0.02	<0.2	0.06	0.06	0.06	0.06	<3	<1
10N/19E-05L01	08-05-92	0.02	<0.2	0.06	0.06	0.05	0.06	<3	<1
	09-08-92	--	--	--	--	--	--	--	--
10N/19E-07R01	08-04-92	0.04	<0.2	0.09	0.09	0.08	0.08	<3	<1
10N/19E-08A01	08-04-92	0.04	<0.2	0.06	0.06	0.06	0.07	<3	<1
10N/19E-21B01	08-05-92	<0.01	<0.2	0.08	0.09	0.08	0.08	<3	<1
10N/19E-21K01	08-04-92	0.02	<0.2	0.08	0.08	0.08	0.08	<3	<1

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Specific conductance (µS/cm)	pH water, whole field (standard units)	Temperature water (°C)	Oxygen, dissolved (mg/L)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)
10N/19E-21M01	08-04-92	325	7.4	14.5	4.4	130	34
10N/19E-25B02	08-05-92	339	7.3	15.0	2.9	150	40
10N/19E-25H02	08-05-92	343	7.4	13.5	1.7	150	40
10N/19E-25H03	03-21-91	397	7.4	13.0	1.0	160	42
	08-04-92	356	7.3	14.0	1.5	160	41
10N/20E-01P01	08-06-92	250	6.9	17.5	1.8	110	27
10N/20E-06N02	08-05-92	281	6.8	27.0	4.5	120	29
10N/20E-07P01	08-05-92	303	7.0	15.0	5.1	120	31
10N/20E-09P01	08-06-92	256	6.9	15.5	3.9	110	27
10N/20E-17F01	08-06-92	294	6.9	14.5	5.0	120	30
	09-08-92	292	7.0	16.0	5.5	--	--
10N/20E-17H01	08-06-92	302	6.9	15.0	4.7	130	31
	09-08-92	298	7.0	17.0	4.5	--	--
10N/20E-17P01	08-06-92	313	6.9	15.0	5.0	130	32
10N/20E-19J01	08-05-92	357	7.1	16.0	3.4	150	38
10N/20E-20K01	08-05-92	344	6.9	15.5	4.2	140	36
10N/20E-20M01	08-05-92	360	7.3	15.0	3.6	150	38
10N/20E-20P01	08-06-92	382	7.4	16.0	3.4	170	43
10N/20E-21B01	08-04-92	308	7.0	14.5	3.4	140	33
10N/20E-21G01	08-04-92	330	7.0	14.5	3.5	150	36
10N/20E-21G02	03-19-91	338	7.1	13.0	3.2	150	37
	08-05-92	341	7.0	14.5	3.2	150	36
10N/20E-21J01	08-04-92	376	6.8	18.0	2.8	160	37
10N/20E-28H02	03-19-91	347	7.1	14.0	3.2	150	38
	08-04-92	351	7.0	16.5	3.4	150	37

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate (mg/L as HCO_3)	Carbonate (mg/L as CO_3)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)
10N/19E-21M01	08-04-92	11	15	3.2	166	0	136	11	6.1
10N/19E-25B02	08-05-92	12	16	3.5	183	0	150	13	5.4
10N/19E-25H02	08-05-92	13	17	3.2	198	0	162	13	5.4
10N/19E-25H03	03-21-91	13	22	4.0	211	0	173	12	6.3
	08-04-92	13	20	3.8	221	0	181	10	4.1
10N/20E-01P01	08-06-92	9.3	9.0	2.0	135	0	110	9.9	4.5
10N/20E-06N02	08-05-92	11	9.0	3.1	134	0	110	11	6.1
10N/20E-07P01	08-05-92	11	10	3.1	150	0	123	11	5.3
10N/20E-09P01	08-06-92	9.6	10	2.1	137	0	112	8.7	5.3
10N/20E-17F01	08-06-92	11	10	2.8	142	0	116	13	5.7
	09-08-92	--	--	--	--	--	--	--	--
10N/20E-17H01	08-06-92	12	11	2.4	158	0	130	13	6.2
	09-08-92	--	--	--	--	--	--	--	--
10N/20E-17P01	08-06-92	12	12	2.9	153	0	125	14	4.6
10N/20E-19J01	08-05-92	13	13	3.3	186	0	153	13	6.1
10N/20E-20K01	08-05-92	13	12	3.2	176	0	144	14	5.9
10N/20E-20M01	08-05-92	13	12	3.2	183	0	150	14	6.1
10N/20E-20P01	08-06-92	14	13	3.6	195	0	160	16	6.0
10N/20E-21B01	08-04-92	13	8	2.4	154	0	126	13	6.7
10N/20E-21G01	08-04-92	14	9	2.5	167	0	137	14	6.9
10N/20E-21G02	03-19-91	14	11	2.8	162	0	133	18	6.7
	08-05-92	14	10	2.7	162	0	133	15	6.2
10N/20E-21J01	08-04-92	17	15	2.5	188	0	154	15	7.7
10N/20E-28H02	03-19-91	14	13	3.0	167	0	137	18	7.0
	08-04-92	14	12	3.1	171	0	140	15	7.1

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 180 °C, dissolved (mg/L)	Nitrogen, nitrite, total (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, NO_2+ NO_3, total (mg/L as N)	Nitrogen, NO_2+ NO_3, dissolved (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)
10N/19E-21M01	08-04-92	0.2	39	209	<0.01	<0.01	3.7	3.7	0.02
10N/19E-25B02	08-05-92	0.1	34	237	<0.01	<0.01	5.5	5.5	0.01
10N/19E-25H02	08-05-92	0.2	33	231	<0.01	<0.01	4.7	4.6	0.01
10N/19E-25H03	03-21-91	0.2	34	255	<0.01	<0.01	5.3	4.3	0.02
	08-04-92	0.1	35	241	<0.01	<0.01	4.0	4.0	0.01
10N/20E-01P01	08-06-92	0.2	29	153	<0.01	<0.01	1.3	1.3	0.02
10N/20E-06N02	08-05-92	0.2	36	181	<0.01	<0.01	5.0	4.9	0.01
10N/20E-07P01	08-05-92	0.1	35	194	<0.01	<0.01	4.6	4.6	0.02
10N/20E-09P01	08-06-92	0.1	34	169	<0.01	<0.01	3.1	3.2	0.01
10N/20E-17F01	08-06-92	<0.1	35	184	<0.01	<0.01	4.4	4.4	0.02
	09-08-92	--	--	--	--	--	--	--	--
10N/20E-17H01	08-06-92	0.1	35	191	<0.01	<0.01	4.5	4.5	<0.01
	09-08-92	--	--	--	--	--	--	--	--
10N/20E-17P01	08-06-92	0.1	35	198	<0.01	<0.01	5.0	4.8	0.02
10N/20E-19J01	08-05-92	0.1	33	218	<0.01	<0.01	4.6	4.6	0.01
10N/20E-20K01	08-05-92	0.1	34	219	<0.01	<0.01	4.5	4.4	<0.01
10N/20E-20M01	08-05-92	0.1	33	221	<0.01	<0.01	4.3	4.3	<0.01
10N/20E-20P01	08-06-92	<0.1	35	236	<0.01	<0.01	4.6	4.6	0.02
10N/20E-21B01	08-04-92	0.2	35	188	<0.01	<0.01	3.8	3.7	0.02
10N/20E-21G01	08-04-92	<0.1	36	207	<0.01	<0.01	4.9	4.9	0.02
10N/20E-21G02	03-19-91	0.1	36	199	<0.01	0.02	5.2	5.2	0.02
	08-05-92	<0.1	36	217	<0.01	<0.01	5.3	5.3	0.01
10N/20E-21J01	08-04-92	0.2	37	233	<0.01	<0.010	5.8	5.7	0.02
10N/20E-28H02	03-19-91	<0.1	36	211	0.01	0.02	4.8	5.8	0.01
	08-04-92	0.1	36	219	<0.01	<0.01	5.6	5.7	0.03

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Phosphorus, total (mg/L as P)	Phosphorus, dissolved (mg/L as P)	Phosphorus ortho, total (mg/L as P)	Phosphorus ortho, dissolved (mg/L as P)	Iron, dissolved (µg/L as Fe)	Manganese, dissolved (µg/L as Mn)
10N/19E-21M01	08-04-92	0.02	<0.2	0.10	0.09	0.09	0.09	<3	<1
10N/19E-25B02	08-05-92	0.02	<0.2	0.07	0.06	0.06	0.06	<3	<1
10N/19E-25H02	08-05-92	0.02	<0.2	0.05	0.05	0.05	0.06	<3	<1
10N/19E-25H03	03-21-91	<0.01	0.2	0.06	0.06	0.06	0.07	13	<1
	08-04-92	0.02	<0.2	0.05	0.06	0.06	0.06	<3	<1
10N/20E-01P01	08-06-92	0.02	<0.2	<0.01	0.02	0.02	0.02	<3	38
10N/20E-06N01	08-05-92	0.02	<0.2	0.04	0.04	0.04	0.05	<3	<1
10N/20E-07P01	08-05-92	0.02	<0.2	0.02	0.03	0.03	0.04	12	2
10N/20E-09P01	08-06-92	0.02	<0.2	0.03	0.02	0.03	0.03	<3	<1
10N/20E-17F01	08-06-92	0.02	<0.2	0.03	0.03	0.04	0.04	<3	<1
	09-08-92	--	--	--	--	--	--	--	--
10N/20E-17H01	08-06-92	<0.01	<0.2	0.02	0.03	0.03	0.03	<3	<1
	09-08-92	--	--	--	--	--	--	--	--
10N/20E-17P01	08-06-92	0.02	<0.2	0.03	0.03	0.04	0.04	<3	<1
10N/20E-19J01	08-05-92	0.02	<0.2	0.05	0.05	0.05	0.05	<3	<1
10N/20E-20K01	08-05-92	<0.01	<0.2	0.02	0.03	0.04	0.04	<3	<1
10N/20E-20M01	08-05-92	<0.01	<0.2	0.05	0.04	0.05	0.05	<3	<1
10N/20E-20P01	08-06-92	0.01	<0.2	0.03	0.04	0.04	0.04	<3	<1
10N/20E-21B01	08-04-92	0.02	<0.2	0.03	0.03	0.04	0.03	<3	<1
10N/20E-21G01	08-04-92	0.02	<0.2	0.02	0.02	0.04	0.03	<3	<1
10N/20E-21G02	03-19-91	<0.01	<0.2	0.03	0.03	<0.01	<0.01	9	<1
	08-05-92	0.01	<0.2	0.02	0.02	0.04	0.04	<3	<1
10N/20E-21J01	08-04-92	0.02	<0.2	0.03	0.05	0.06	0.05	<3	<1
10N/20E-28H02	03-19-91	<0.01	0.2	0.05	0.04	<0.01	<0.01	7	1
	08-04-92	0.04	<0.2	0.03	0.03	0.03	0.04	<3	<1

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Specific conductance (μS/cm)	pH water, whole field (standard units)	Temperature water (°C)	Oxygen, dissolved (mg/L)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)
10N/20E-29E01	03-21-91	368	7.3	13.5	2.5	150	38
	08-04-92	369	7.0	20.5	3.0	150	39
10N/21E-33B02	08-07-92	404	7.1	14.5	0.2	160	38
	09-08-92	401	7.1	16.0	0.2	--	--
11N/16E-25N01	08-07-92	675	7.4	17.0	7.0	300	67
11N/16E-35J01	08-07-92	378	7.5	15.5	6.2	160	33
11N/18E-10C01	03-21-91	570	7.6	14.5	9.6	200	50
	08-06-92	552	7.5	16.0	9.1	190	46
11N/18E-10J01	08-06-92	648	7.6	14.5	5.8	220	50
11N/18E-22D01	03-20-91	676	7.6	12.0	4.2	260	68
	08-06-92	678	7.6	17.0	4.8	240	63
11N/18E-22R01	08-06-92	347	7.3	15.0	6.5	140	38
	09-09-92	338	7.3	15.0	5.5	--	--
11N/18E-22R02	03-20-91	360	7.1	13.5	6.3	150	42
	08-06-92	338	7.2	14.5	5.9	140	36
11N/18E-26P01	08-07-92	394	7.2	14.0	7.8	170	45
	09-09-92	406	7.2	15.0	7.8	--	--
11N/18E-27N01	03-20-91	544	7.4	13.5	5.7	230	59
	08-06-92	479	7.4	14.5	5.4	190	48
11N/18E-27R02	03-20-91	390	7.2	13.5	6.1	170	45
	08-06-92	337	7.3	14.5	6.5	140	36
11N/18E-29N01	08-06-92	589	7.3	14.5	1.7	220	51
	09-09-92	592	7.4	18.0	1.8	--	--
11N/18E-31A01	03-19-91	779	7.3	--	0.1	--	--
	08-05-92	822	7.2	16.5	0.6	360	81
11N/18E-36R01	08-05-92	279	7.0	15.5	5.0	110	28
	09-09-92	285	7.0	17.0	4.9	--	--
11N/19E-17N01	08-04-92	280	6.7	14.5	6.8	130	31

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate (mg/L as HCO_3)	Carbonate (mg/L as CO_3)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)
10N/20E-29E01	03-21-91	13	18	3.8	195	0	160	13	6.9
	08-04-92	13	18	3.8	195	0	160	14	6.6
10N/21E-33B02	08-07-92	16	21	4.5	205	0	168	16	11
	09-08-92	--	--	--	--	--	--	--	--
11N/16E-25N01	08-07-92	31	26	3.1	364	0	298	29	20
11N/16E-35J01	08-07-92	18	15	3.7	122	0	100	16	9.9
11N/18E-10C01	03-21-91	19	29	3.7	105	0	86	22	34
	08-06-92	18	27	3.6	105	0	86	30	33
11N/18E-10J01	08-06-92	24	55	3.5	379	0	310	24	9.6
11N/18E-22D01	03-20-91	22	49	6.5	355	0	291	24	13
	08-06-92	21	45	6.0	356	0	292	26	13
11N/18E-22R01	08-06-92	11	14	4.2	170	0	139	15	7.8
	09-09-92	--	--	--	--	--	--	--	--
11N/18E-22R02	03-20-91	12	15	4.1	167	0	137	16	7.6
	08-06-92	11	15	3.8	164	0	134	15	6.2
11N/18E-26P01	08-07-92	13	12	3.8	195	0	160	16	8.9
	09-09-92	--	--	--	--	--	--	--	--
11N/18E-27N01	03-20-91	20	25	5.4	249	0	204	27	12
	08-06-92	16	22	4.8	223	0	183	22	13
11N/18E-27R02	03-20-91	13	16	4.5	188	0	154	21	7.1
	08-06-92	11	13	3.9	167	0	137	15	7.0
11N/18E-29N01	08-06-92	23	37	4.8	320	0	270	25	11
	09-09-92	--	--	--	--	--	--	---	-
11N/18E-31A01	03-19-91	--	--	--	--	--	--	--	--
	08-05-92	38	32	6.0	434	0	356	53	14
11N/18E-36R01	08-05-92	9.8	11	3.4	137	0	112	10	9.4
	09-09-92	--	--	--	--	--	--	--	--
11N/19E-17N01	08-04-92	13	10	3.4	156	0	128	11	5.8

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 180 °C, dissolved (mg/L)	Nitrogen, nitrite, total (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, total (mg/L as N)	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)
10N/20E-29E01	03-21-91	0.1	34	220	<0.01	<0.01	4.8	5.0	0.02
	08-04-92	0.1	36	229	<0.01	<0.01	4.3	5.0	0.03
10N/21E-33B02	08-07-92	0.3	41	249	0.03	0.04	4.3	4.3	0.01
	09-08-92	--	--	--	--	--	--	--	--
11N/16E-25N01	08-07-92	0.6	55	408	<0.01	<0.01	4.5	4.6	0.01
11N/16E-35J01	08-07-92	0.4	59	243	<0.01	<0.01	2.6	2.5	<0.01
11N/18E-10C01	03-21-91	0.3	59	383	<0.01	<0.01	27	30	<0.01
	08-06-92	0.3	60	416	<0.01	<0.01	28	28	<0.01
11N/18E-10J01	08-06-92	0.8	60	418	<0.01	<0.01	6.7	6.6	<0.01
11N/18E-22D01	03-20-91	0.4	40	425	0.01	<0.01	9.0	9.6	0.02
	08-06-92	0.4	40	420	<0.01	<0.01	8.7	8.6	<0.01
11N/18E-22R01	08-06-92	0.2	37	220	<0.01	<0.01	4.5	4.4	<0.01
	09-09-92	--	--	--	--	--	--	--	--
11N/18E-22R02	03-20-91	0.2	34	220	<0.01	0.01	7.4	7.5	0.01
	08-06-92	0.2	34	223	<0.01	<0.01	4.7	4.7	0.01
11N/18E-26P01	08-07-92	0.2	32	252	<0.01	<0.01	5.8	5.7	<0.01
	09-09-92	--	--	--	--	--	--	--	--
11N/18E-27N01	03-20-91	0.2	40	337	<0.01	0.02	12	12	0.01
	08-06-92	0.2	40	306	<0.01	<0.01	8.0	7.8	<0.01
11N/18E-27R02	03-20-91	0.2	37	245	<0.01	0.01	6.4	6.3	0.03
	08-06-92	0.2	36	218	<0.01	<0.01	4.3	4.3	<0.01
11N/18E-29N01	08-06-92	0.3	51	356	<0.01	<0.01	3.8	3.8	0.02
	09-09-92	--	--	--	--	--	--	--	--
11N/18E-31A01	03-19-91	--	--	--	--	--	6.5	--	0.01
	08-05-92	0.2	52	517	0.11	0.12	9.2	9.2	0.01
11N/18E-36R01	08-05-92	0.1	33	176	<0.01	<0.01	1.8	1.8	0.02
	09-09-92	--	--	--	--	--	--	--	--
11N/19E-17N01	08-04-92	0.1	35	188	<0.01	<0.01	2.7	2.7	0.02

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Phosphorus, total (mg/L as P)	Phosphorus, dissolved (mg/L as P)	Phosphorus ortho, total (mg/L as P)	Phosphorus ortho, dissolved (mg/L as P)	Iron, dissolved (µg/L as Fe)	Manganese, dissolved (µg/L as Mn)
10N/20E-29E01	03-21-91	0.02	0.3	0.07	0.06	0.06	0.07	7	1
	08-04-92	0.03	<0.2	0.06	0.07	0.06	0.07	<3	<1
10N/21E-33B02	08-07-92	<0.01	<0.2	0.03	0.04	0.040	0.04	5	41
	09-08-92	--	--	--	--	--	--	--	--
11N/16E-25N01	08-07-92	<0.01	<0.2	0.04	0.04	0.04	0.05	6	1
11N/16E-35J01	08-07-92	<0.01	<0.2	0.05	0.05	0.05	0.06	<3	<1
11N/18E-10C01	03-21-91	<0.01	0.5	0.02	<0.01	0.02	0.02	19	2
	08-06-92	<0.01	<0.2	<0.01	<0.01	0.01	0.02	7	<1
11N/18E-10J01	08-06-92	<0.01	<0.2	<0.01	<0.01	0.02	0.02	<3	<1
11N/18E-22D01	03-20-91	<0.01	0.4	0.06	0.06	0.07	0.08	<3	<1
	08-06-92	<0.01	<0.2	0.07	0.07	0.07	0.07	<3	<1
11N/18E-22R01	08-06-92	<0.01	<0.2	0.07	0.07	0.07	0.08	<3	<1
	09-09-92	--	--	--	--	--	--	--	--
11N/18E-22R02	03-20-91	<0.01	0.4	0.08	0.10	0.05	<0.01	6	1
	08-06-92	<0.01	<0.2	0.11	0.11	0.11	0.10	<3	<1
11N/18E-26P01	08-07-92	<0.01	<0.2	0.05	0.06	0.06	0.06	<3	<1
	09-09-92	--	--	--	--	--	--	--	--
11N/18E-27N01	03-20-91	<0.01	0.5	0.07	0.07	0.02	<0.01	6	<1
	08-06-92	<0.01	<0.2	0.06	0.07	0.07	0.07	<3	<1
11N/18E-27R02	03-20-91	<0.01	0.4	0.06	0.06	0.03	<0.01	5	<1
	08-06-92	<0.01	<0.2	0.07	0.07	0.07	0.07	<3	<1
11N/18E-29N01	08-06-92	0.02	<0.2	0.54	0.56	0.51	0.51	10	2
	09-09-92	--	--	--	--	--	--	--	--
11N/18E-31A01	03-19-91	--	0.3	--	--	--	--	--	--
	08-05-92	<0.01	<0.2	0.34	0.34	0.30	0.29	7	740
11N/18E-36R01	08-05-92	0.02	<0.2	0.05	0.06	0.07	0.07	<3	<1
	09-09-92	--	--	--	--	--	--	--	--
11N/19E-17N01	08-04-92	0.02	<0.2	0.11	0.11	0.11	0.11	<3	<1

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Specific conductance (μS/cm)	pH water, whole field (standard units)	Temperature water (°C)	Oxygen, dissolved (mg/L)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)
11N/19E-23Q03	08-03-92	140	6.7	16.0	5.0	64	16
11N/19E-28A01	08-03-92	305	6.9	15.5	6.4	130	34
11N/19E-29N01	03-19-91	280	6.9	14.0	6.1	120	30
	08-03-92	264	6.6	14.5	6.8	110	27
11N/19E-35A02	08-03-92	270	6.8	15.5	7.4	120	29
11N/19E-36P01	08-05-92	270	6.8	19.5	6.7	110	27
11N/20E-33N04	08-07-92	210	6.8	14.5	5.4	87	22
12N/19E-29G01	03-21-91	641	7.7	--	2.1	190	43
	08-07-92	541	7.6	16.0	5.2	170	37

Local well number	Date	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate (mg/L as HCO_3)	Carbonate (mg/L as CO_3)	Alkalinity (mg/L as $CaCO_3$)	Sulfate dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)
11N/19E-23Q03	08-03-92	5.8	6	1.9	79	0	65	5.5	3.3
11N/19E-28A01	08-03-92	12	11	3.4	134	0	110	17	6.2
11N/19E-29N01	03-19-91	11	11	3.3	143	0	117	9.5	5.4
	08-03-92	11	10	3.3	139	0	114	9.6	5.4
11N/19E-35A02	08-03-92	11	10	2.8	137	0	112	10	6.3
11N/19E-36P01	08-05-92	10	10	3.0	120	0	98	12	6.0
11N/20E-33N04	08-07-92	7.8	8	1.9	95	0	78	7.9	5.4
12N/19E-29G01	03-21-91	21	65	6.4	282	0	231	96	13
	08-07-92	18	51	5.7	287	0	235	42	12

Table 7.--*Field measurements and concentrations of common constituents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 180 °C, dissolved (mg/L)	Nitrogen, nitrite, total (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, NO_2+ NO_3, total (mg/L as N)	Nitrogen, NO_2+ NO_3, dissolved (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)
11N/19E-23Q03	08-03-92	<0.1	29	119	<0.01	<0.01	1.3	1.3	0.02
11N/19E-28A01	08-03-92	0.1	33	209	<0.01	<0.01	7.3	7.3	0.01
11N/19E-29N01	03-19-91	0.1	36	172	<0.01	<0.01	3.1	3.2	0.01
	08-03-92	0.1	36	177	<0.01	<0.01	2.7	2.8	0.01
11N/19E-35A02	08-03-92	0.1	35	185	<0.01	<0.01	4.1	4.2	0.03
11N/19E-36P01	08-05-92	0.1	36	179	<0.01	<0.01	5.1	5.1	0.01
11N/20E-33N04	08-07-92	<0.1	30	144	<0.01	<0.01	3.9	3.9	<0.01
12N/19E-29G01	03-21-91	0.6	52	431	<0.01	<0.01	<0.05	<0.05	0.02
	08-07-92	0.6	52	344	<0.01	<0.01	0.22	0.23	<0.01

Local well number	Date	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Phosphorus, total (mg/L as P)	Phosphorus, dissolved (mg/L as P)	Phosphorus ortho, total (mg/L as P)	Phosphorus ortho, dissolved (mg/L as P)	Iron, dissolved (µg/L as Fe)	Manganese, dissolved (µg/L as Mn)
11N/19E-23Q03	08-03-92	0.04	<0.2	0.03	0.03	0.03	0.04	4	<1
11N/19E-28A01	08-03-92	0.01	<0.2	0.06	0.05	0.05	0.05	9	2
11N/19E-29N01	03-19-91	<0.01	<0.2	0.33	0.08	0.02	<0.01	9	3
	08-03-92	<0.01	<0.2	0.07	0.07	0.07	0.08	3	<1
11N/19E-35A02	08-03-92	0.03	<0.2	0.04	0.03	0.04	0.04	9	<1
11N/19E-36P01	08-05-92	<0.01	<0.2	0.07	0.07	0.07	0.07	<3	<1
11N/20E-33N04	08-07-92	<0.01	<0.2	0.02	0.02	0.02	0.03	130	1
12N/19E-29G01	03-21-91	<0.01	<0.2	0.14	0.12	0.14	0.14	14	8
	08-07-92	<0.01	<0.2	0.18	0.20	0.18	0.19	<3	3

Table 8.--*Concentrations of selected trace elements in ground-water samples collected during the intensive sampling program*

[µg/L, micrograms per liter; --, no data]

Local well number	Date	Aluminum, dissolved (µg/L as Al)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)
10N/17E-29A01	08-06-92	<10	--	<2	--	--
10N/18E-02N01	08-06-92	<10	--	12	--	--
10N/18E-02Q01	03-20-91	<10	1	16	<0.5	<1.0
	08-05-92	<10	--	15	--	--
	09-08-92	--	--	--	--	--
10N/18E-02R01	08-05-92	<10	--	13	--	--
10N/18E-04C01	08-04-92	<10	--	11	--	--
10N/18E-04Q01	08-04-92	<10	--	13	--	--
10N/18E-06R04	08-04-92	<10	--	43	--	--
10N/18E-15A01	03-19-91	<10	1	12	<0.5	<1.0
	08-04-92	<10	--	9	--	--
10N/18E-15H01	03-19-91	<10	2	10	<0.5	<1.0
	08-04-92	10	--	10	--	--
10N/18E-36A01	03-19-91	10	<1	23	<0.5	<1.0
	08-04-92	<10	--	21	--	--
10N/19E-01J01	08-04-92	<10	--	8	--	--
10N/19E-03A01	08-05-92	<10	--	10	--	--
10N/19E-05L01	08-05-92	10	--	8	--	--
	09-08-92	--	--	--	--	--
10N/19E-07R01	08-04-92	<10	--	7	--	--
10N/19E-08A01	08-04-92	<10	--	7	--	--
10N/19E-21B01	08-05-92	<10	--	7	--	--
10N/19E-21K01	08-04-92	<10	--	9	--	--

Table 8.--*Concentrations of selected trace elements in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)
10N/17E-29A01	08-06-92	--	<3	--	--	8	<0.1	<10
10N/18E-02N01	08-06-92	--	<3	--	--	<4	<0.1	<10
10N/18E-02Q01	03-20-91	2	<3	1	<1	4	<0.1	<10
	08-05-92	--	<3	--	--	<4	<0.1	<10
	09-08-92	--	--	--	--	--	--	--
10N/18E-02R01	08-05-92	--	<3	--	--	<4	<0.1	<10
10N/18E-04C01	08-04-92	--	<3	--	--	6	<0.1	<10
10N/18E-04Q01	08-04-92	--	<3	--	--	<4	<0.1	<10
10N/18E-06R04	08-04-92	--	<3	--	--	6	<0.1	<10
10N/18E-15A01	03-19-91	<1	<3	6	1	<4	<0.1	<10
	08-04-92	--	<3	--	--	4	<0.1	<10
10N/18E-15H01	03-19-91	<1	<3	15	<1	4	0.1	<10
	08-04-92	--	<3	--	--	<4	--	<10
10N/18E-36A01	03-19-91	2	<3	3	<1	9	<0.1	<10
	08-04-92	--	<3	--	--	6	--	<10
10N/19E-01J01	08-04-92	--	<3	--	--	<4	<0.1	<10
10N/19E-03A01	08-05-92	--	<3	--	--	<4	--	<10
10N/19E-05L01	08-05-92	--	<3	--	--	<4	--	<10
	09-08-92	--	--	--	--	--	--	--
10N/19E-07R01	08-04-92	--	<3	--	--	<4	<0.1	<10
10N/19E-08A01	08-04-92	--	<3	--	--	<4	<0.1	<10
10N/19E-21B01	08-05-92	--	<3	--	--	<4	--	<10
10N/19E-21K01	08-04-92	--	<3	--	--	<4	<0.1	<10

Table 8.--*Concentrations of selected trace elements in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Nickel, dis-solved (µg/L as Ni)	Sele-nium, dis-solved (µg/L as Se)	Silver, dis-solved (µg/L as Ag)	Stron-tium, dis-solved (µg/L as Sr)	Vana-dium, dis-solved (µg/L as V)	Zinc, dis-solved (µg/L as Zn)
10N/17E-29A01	08-06-92	<1	<1	<1.0	73	7	--
10N/18E-02N01	08-06-92	<1	<1	<1.0	190	9	--
10N/18E-02Q01	03-20-91	1	<1	<1.0	170	7	21
	08-05-92	<1	<1	<1.0	180	6	--
	09-08-92	--	--	--	--	--	--
10N/18E-02R01	08-05-92	<1	<1	<1.0	180	10	--
10N/18E-04C01	08-04-92	<1	1	<1.0	190	20	--
10N/18E-04Q01	08-04-92	<1	2	<1.0	210	18	--
10N/18E-06R04	08-04-92	<1	<1	<1.0	220	24	--
10N/18E-15A01	03-19-91	1	<1	<1.0	200	11	21
	08-04-92	<1	<1	<1.0	190	15	--
10N/18E-15H01	03-19-91	17	<1	<1.0	190	11	42
	08-04-92	<1	<1	<1.0	190	14	--
10N/18E-36A01	03-19-91	1	1	<1.0	480	25	40
	08-04-92	<1	<1	<1.0	460	27	--
10N/19E-01J01	08-04-92	<1	<1	<1.0	130	<6	--
10N/19E-03A01	08-05-92	<1	<1	<1.0	130	<6	--
10N/19E-05L01	08-05-92	1	<1	<1.0	130	<6	--
	09-08-92	--	--	--	--	--	--
10N/19E-07R01	08-04-92	<1	<1	<1.0	150	12	--
10N/19E-08A01	08-04-92	<1	<1	<1.0	130	6	--
10N/19E-21B01	08-05-92	<1	<1	<1.0	140	10	--
10N/19E-21K01	08-04-92	<1	<1	<1.0	140	8	--

Table 8.--*Concentrations of selected trace elements in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Alum-inum, dis-solved (µg/L as Al)	Arsenic, dis-solved (µg/L as As)	Barium, dis-solved (µg/L as Ba)	Beryl-lium, dis-solved (µg/L as Be)	Cadmium, dis-solved (µg/L as Cd)
10N/19E-21M01	08-04-92	<10	--	7	--	--
10N/19E-25B02	08-05-92	<10	--	11	--	--
10N/19E-25H02	08-05-92	20	--	11	--	--
10N/19E-25H03	03-21-91	<10	<1	13	<0.5	<1.0
	08-04-92	<10	--	12	--	--
10N/20E-01P01	08-06-92	<10	--	9	--	--
10N/20E-06N02	08-05-92	<10	--	9	--	--
10N/20E-07P01	08-05-92	<10	--	10	--	--
10N/20E-09P01	08-06-92	<10	--	8	--	--
10N/20E-17F01	08-06-92	<10	--	9	--	--
	09-08-92	--	--	--	--	--
10N/20E-17H01	08-06-92	<10	--	7	--	--
	09-08-92	--	--	--	--	--
10N/20E-17P01	08-06-92	<10	--	10	--	--
10N/20E-19J01	08-05-92	<10	--	10	--	--
10N/20E-20K01	08-05-92	<10	--	10	--	--
10N/20E-20M01	08-05-92	<10	--	9	--	--
10N/20E-20P01	08-06-92	10	--	10	--	--
10N/20E-21B01	08-04-92	<10	--	7	--	--
10N/20E-21G01	08-04-92	<10	--	9	--	--
10N/20E-21G02	03-19-91	20	<1	10	<0.5	1.0
	08-05-92	<10	--	9	--	--
10N/20E-21J01	08-04-92	<10	--	11	--	--
10N/20E-28H02	03-19-91	10	<1	11	<0.5	<1.0
	08-04-92	<10	--	10	--	--
10N/20E-29E01	03-21-91	<10	<1	11	<0.5	<1.0
	08-04-92	<10	--	11	--	--

Table 8.--*Concentrations of selected trace elements in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)
10N/19E-21M01	08-04-92	--	<3	--	--	<4	<0.1	<10
10N/19E-25B02	08-05-92	--	<3	--	--	4	<0.1	<10
10N/19E-25H02	08-05-92	--	<3	--	--	<4	--	<10
10N/19E-25H03	03-21-91	2	<3	2	<1	<4	<0.1	<10
	08-04-92	--	<3	--	--	5	<0.1	<10
10N/20E-01P01	08-06-92	--	<3	--	--	<4	<0.1	<10
10N/20E-06N02	08-05-92	--	<3	--	--	<4	--	<10
10N/20E-07P01	08-05-92	--	<3	--	--	<4	<0.1	<10
10N/20E-09P01	08-06-92	--	<3	--	--	<4	--	<10
10N/20E-17F01	08-06-92	--	<3	--	--	<4	<0.1	<10
	09-08-92	--	--	--	--	--	--	--
10N/20E-17H01	08-06-92	--	<3	--	--	<4	<0.1	<10
	09-08-92	--	--	--	--	--	--	--
10N/20E-17P01	08-06-92	--	<3	--	--	<4	<0.1	<10
10N/20E-19J01	08-05-92	--	<3	--	--	<4	<0.1	<10
10N/20E-20K01	08-05-92	--	<3	--	--	<4	<0.1	<10
10N/20E-20M01	08-05-92	--	<3	--	--	<4	<0.1	<10
10N/20E-20P01	08-06-92	--	<3	--	--	<4	<0.1	<10
10N/20E-21B01	08-04-92	--	<3	--	--	<4	<0.1	<10
10N/20E-21G01	08-04-92	--	<3	--	--	<4	<0.1	<10
10N/20E-21G02	03-19-91	2	<3	2	<1	<4	<0.1	<10
	08-05-92	--	<3	--	--	<4	<0.1	<10
10N/20E-21J01	08-04-92	--	<3	--	--	<4	<0.1	<10
10N/20E-28H02	03-19-91	<1	<3	36	<1	<4	<0.1	<10
	08-04-92	--	<3	--	--	<4	<0.1	<10
10N/20E-29E01	03-21-91	1	<3	3	<1	<4	<0.1	<10
	08-04-92	--	<3	--	--	<4	<0.1	<10

Table 8.--*Concentrations of selected trace elements in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Nickel, dissolved (µg/L as Ni)	Selenium, dissolved (µg/L as Se)	Silver, dissolved (µg/L as Ag)	Strontium, dissolved (µg/L as Sr)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)
10N/19E-21M01	08-04-92	<1	<1	<1.0	150	11	--
10N/19E-25B02	08-05-92	<1	<1	<1.0	170	8	--
10N/19E-25H02	08-05-92	<1	<1	<1.0	170	8	--
10N/19E-25H03	03-21-91	1	<1	<1.0	180	9	180
	08-04-92	<1	<1	<1.0	170	9	--
10N/20E-01P01	08-06-92	<1	<1	<1.0	110	<6	--
10N/20E-06N02	08-05-92	<1	<1	<1.0	130	<6	--
10N/20E-07P01	08-05-92	<1	<1	<1.0	140	<6	--
10N/20E-09P01	08-06-92	<1	<1	<1.0	120	<6	--
10N/20E-17F01	08-06-92	<1	<1	<1.0	130	<6	--
	09-08-92	--	--	--	--	--	--
10N/20E-17H01	08-06-92	<1	<1	<1.0	140	<6	--
	09-08-92	--	--	--	--	--	--
10N/20E-17P01	08-06-92	<1	<1	<1.0	140	<6	--
10N/20E-19J01	08-05-92	<1	<1	<1.0	160	7	--
10N/20E-20K01	08-05-92	<1	<1	<1.0	150	6	--
10N/20E-20M01	08-05-92	<1	<1	<1.0	160	8	--
10N/20E-20P01	08-06-92	<1	<1	<1.0	180	7	--
10N/20E-21B01	08-04-92	<1	<1	<1.0	140	<6	--
10N/20E-21G01	08-04-92	<1	<1	<1.0	150	<6	--
10N/20E-21G02	03-19-91	4	<1	<1.0	150	<6	8
	08-05-92	<1	<1	<1.0	150	<6	--
10N/20E-21J01	08-04-92	<1	<1	<1.0	140	<6	--
10N/20E-28H02	03-19-91	2	<1	<1.0	160	<6	140
	08-04-92	<1	<1	<1.0	160	<6	--
10N/20E-29E01	03-21-91	<1	<1	<1.0	160	7	52
	08-04-92	<1	<1	<1.0	160	8	--

Table 8.--*Concentrations of selected trace elements in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Aluminum, dissolved (μg/L as Al)	Arsenic, dissolved (μg/L as As)	Barium, dissolved (μg/L as Ba)	Beryllium, dissolved (μg/L as Be)	Cadmium, dissolved (μg/L as Cd)
10N/21E-33B02	08-07-92	20	--	15	--	--
	09-08-92	--	--	--	--	--
11N/16E-25N01	08-07-92	<10	--	30	--	--
11N/16E-35J01	08-07-92	20	--	15	--	--
11N/18E-10C01	03-21-91	<10	2	150	<0.5	<1.0
	08-06-92	<10	--	130	--	--
11N/18E-10J01	08-06-92	<10	--	120	--	--
11N/18E-22D01	03-20-91	<10	4	26	<0.5	<1.0
	08-06-92	<10	--	25	--	--
11N/18E-22R01	08-06-92	<10	--	16	--	--
	09-09-92	--	--	--	--	--
11N/18E-22R02	03-20-91	20	2	13	<0.5	<1.0
	08-06-92	<10	--	11	--	--
11N/18E-26P01	08-07-92	<10	--	19	--	--
	09-09-92	--	--	--	--	--
11N/18E-27N01	03-20-91	<10	1	21	<0.5	<1.0
	08-06-92	<10	--	16	--	--
11N/18E-27R02	03-20-91	20	2	17	<0.5	<1.0
	08-06-92	<10	--	12	--	--
11N/18E-29N01	08-06-92	20	--	16	--	--
	09-09-92	--	--	--	--	--
11N/18E-31A01	03-19-91	--	--	--	--	--
	08-05-92	<10	--	35	--	--
11N/18E-36R01	08-05-92	<10	--	8	--	--
	09-09-92	--	--	--	--	--
11N/19E-17N01	08-04-92	<10	--	11	--	--
11N/19E-23Q03	08-03-92	40	--	5	--	--
11N/19E-28A01	08-03-92	<10	--	9	--	--
11N/19E-29N01	03-19-91	<10	<1	10	<0.5	1.0
	08-03-92	<10	--	9	--	--

Table 8.--*Concentrations of selected trace elements in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)
10N/21E-33B02	08-07-92	--	<3	--	--	<4	<0.1	<10
	09-08-92	--	--	--	--	--	--	--
11N/16E-25N01	08-07-92	--	<3	--	--	<4	<0.1	<10
11N/16E-35J01	08-07-92	--	<3	--	--	<4	<0.1	<10
11N/18E-10C01	03-21-91	2	<3	1	<1	10	<0.1	<10
	08-06-92	--	<3	--	--	10	<0.1	<10
11N/18E-10J01	08-06-92	--	<3	--	--	7	<0.1	20
11N/18E-22D01	03-20-91	2	<3	21	<1	7	<0.1	10
	08-06-92	--	<3	--	--	7	<0.1	10
11N/18E-22R01	08-06-92	--	<3	--	--	5	<0.1	<10
	09-09-92	--	--	--	--	--	--	--
11N/18E-22R02	03-20-91	<1	<3	11	<1	<4	0.2	<10
	08-06-92	--	<3	--	--	5	<0.1	<10
11N/18E-26P01	08-07-92	--	<3	--	--	5	<0.1	<10
	09-09-92	--	--	--	--	--	--	--
11N/18E-27N01	03-20-91	1	<3	3	<1	5	<0.1	<10
	08-06-92	--	<3	--	--	6	<0.1	<10
11N/18E-27R02	03-20-91	<1	<3	29	<1	<4	<0.1	<10
	08-06-92	--	<3	--	--	5	<0.1	<10
11N/18E-29N01	08-06-92	--	<3	--	--	<4	<0.1	<10
	09-09-92	--	--	--	--	--	--	--
11N/18E-31A01	03-19-91	--	--	--	--	--	--	--
	08-05-92	--	<3	--	--	<4	<0.1	<10
11N/18E-36R01	08-05-92	--	<3	--	--	4	<0.1	<10
	09-09-92	--	--	--	--	--	--	--
11N/19E-17N01	08-04-92	--	<3	--	--	6	<0.1	<10
11N/19E-23Q03	08-03-92	--	<3	--	--	<4	--	<10
11N/19E-28A01	08-03-92	--	<3	--	--	<4	--	<10
11N/19E-29N01	03-19-91	2	<3	2	1	<4	<0.1	<10
	08-03-92	--	<3	--	--	<4	--	<10

Table 8.--*Concentrations of selected trace elements in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Nickel, dis-solved (µg/L as Ni)	Sele-nium, dis-solved (µg/L as Se)	Silver, dis-solved (µg/L as Ag)	Stron-tium, dis-solved (µg/L as Sr)	Vana-dium, dis-solved (µg/L as V)	Zinc, dis-solved (µg/L as Zn)
10N/21E-33B02	08-07-92	2	<1	<1.0	160	<6	--
	09-08-92	--	--	--	--	--	--
11N/16E-25N01	08-07-92	<1	<1	<1.0	280	31	--
11N/16E-35J01	08-07-92	<1	<1	<1.0	110	31	--
11N/18E-10C01	03-21-91	1	<1	<1.0	350	28	120
	08-06-92	<1	3	<1.0	320	30	--
11N/18E-10J01	08-06-92	<1	1	<1.0	370	91	--
11N/18E-22D01	03-20-91	1	<1	<1.0	340	13	45
	08-06-92	<1	1	<1.0	330	14	--
11N/18E-22R01	08-06-92	<1	<1	<1.0	170	8	--
	09-09-92	--	--	--	--	--	--
11N/18E-22R02	03-20-91	1	<1	<1.0	180	<6	52
	08-06-92	<1	<1	<1.0	160	<6	--
11N/18E-26P01	08-07-92	<1	<1	<1.0	190	7	--
	09-09-92	--	--	--	--	--	--
11N/18E-27N01	03-20-91	<1	<1	<1.0	280	10	110
	08-06-92	<1	<1	<1.0	240	11	--
11N/18E-27R02	03-20-91	<1	<1	<1.0	210	<6	5
	08-06-92	<1	<1	<1.0	170	8	--
11N/18E-29N01	08-06-92	<1	1	<1.0	220	31	--
	09-09-92	--	--	--	--	--	--
11N/18E-31A01	03-19-91	--	--	--	--	--	--
	08-05-92	<1	<1	<1.0	370	22	--
11N/18E-36R01	08-05-92	<1	<1	<1.0	130	<6	--
	09-09-92	--	--	--	--	--	--
11N/19E-17N01	08-04-92	2	<1	<1.0	130	<6	--
11N/19E-23Q03	08-03-92	<1	<1	<1.0	67	<6	--
11N/19E-28A01	08-03-92	2	<1	<1.0	130	7	--
11N/19E-29N01	03-19-91	1	<1	<1.0	130	<6	9
	08-03-92	2	<1	<1.0	120	<6	--

Table 8.--*Concentrations of selected trace elements in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Aluminum, dissolved (µg/L as Al)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)
11N/19E-35A02	08-03-92	<10	--	9	--	--
11N/19E-36P01	08-05-92	<10	--	9	--	--
11N/20E-33N04	08-07-92	<10	--	7	--	--
12N/19E-29G01	03-21-91	<10	2	36	<0.5	<1.0
	08-07-92	<10	--	27	--	--

Local well number	Date	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)
11N/19E-35A02	08-03-92	--	<3	--	--	<4	--	<10
11N/19E-36P01	08-05-92	--	<3	--	--	<4	<0.1	<10
11N/20E-33N04	08-07-92	--	<3	--	--	<4	<0.1	<10
12N/19E-29G01	03-21-91	<1	<3	2	<1	17	4.0	<10
	08-07-92	--	<3	--	--	16	<0.1	10

Local well number	Date	Nickel, dissolved (µg/L as Ni)	Selenium, dissolved (µg/L as Se)	Silver, dissolved (µg/L as Ag)	Strontium, dissolved (µg/L as Sr)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)
11N/19E-35A02	08-03-92	<1	<1	<1.0	130	<6	--
11N/19E-36P01	08-05-92	<1	<1	<1.0	120	<6	--
11N/20E-33N04	08-07-92	<1	<1	<1.0	92	<6	--
12N/19E-29G01	03-21-91	3	<1	<1.0	150	<6	65
	08-07-92	2	<1	<1.0	130	11	--

Pesticides were detected in 6 of the 60 wells sampled during the intensive sampling phase of the project. Atrazine, a nitrogen-based herbicide used to control broadleafed weeds in asparagus and corn, was detected in water samples from four wells (11N/18E-22R01, 11N/18E-22R02, 11N/19E-23Q03, and 11N/19E-35A02; table 9 and fig. 6). The highest concentration detected was 0.2 µg/L in the sample from well 11N/19E-35A02. The concentrations in samples from the other three wells were at the minimum reporting level for this compound (0.1 µg/L). Even though the concentrations were less than the USEPA limit of 3 µg/L, the presence of any pesticide in water indicates a potential for larger concentrations.

Diazinon, an insecticide used on hops, was detected in samples from two wells (10N/19E-25B02 and 11N/18E-10C01) and disulfoton, an insecticide used on asparagus and lettuce, was detected in one of a pair of replicate samples from well 10N/20E-9P01. Concentrations of both of these pesticides were at the minimum reporting level for these compounds (0.01 µg/L for both diazinon and disulfoton). These results indicate that pesticides may be present at small concentrations in some parts of the basin--below the minimum reporting level for the analytical method used. There are no drinking water standards for these two pesticides but the USEPA has published health advisories for long-term exposure (greater than 10 days) at 20 µg/L for diazinon and 9 µg/L for disulfoton (U.S. Environmental Protection Agency, 1994).

Bacteria

Fecal-coliform bacteria, indicators of the fecal contamination of water, were detected in samples from 8 of the 487 wells during the synoptic sampling phase (Payne and Sumioka, 1994, Appendix table 1). *E. coli* bacteria, a species in the fecal-coliform group, were detected in 7 of the 487 wells sampled during the synoptic sampling phase (Payne and Sumioka, 1994). This organism was included in the synoptic sampling phase because it has been shown that for surface waters used for recreation, it is more specific for fecal contamination and provides a better indicator-to-pathogen ratio than fecal-coliform bacteria (Freier and Hartman, 1987). This study provided an opportunity to investigate the occurrence and distribution of *E. coli* in ground water in the basin.

Fecal-streptococcal bacteria were used in this study as a third indicator of fecal contamination of water. Fecal streptococci are found in the intestinal tract of warm-blooded animals; however, non-fecal streptococci subspecies that can be found in insects, in soil, and on vegetation will also grow on the test medium, so the presence of colonies on the streptococci growth medium alone does not indicate fecal contamination. Fecal-streptococcal data are used in conjunction with fecal-coliform data to provide information on how recently exposure occurred and the possible origin of contamination. During the synoptic sampling phase, samples from 64 of 487 wells produced positive fecal-streptococcal results. Even though these results indicate a bacteriological problem with the water of some wells, positive results from a single sample do not necessarily indicate contamination of the aquifer. Other possible sources of the bacteria include leaks in the plumbing system of the well or residence, or improper well construction.

Fecal-coliform bacteria and *E. coli* were detected in 1 sample from each of the series of samples from 2 of the 20 wells used in the seasonal sampling phase (table 6). Fecal streptococci were detected in samples from 8 of 20 wells. However, only one well had more than two samples with positive counts out of the nine samples collected during this phase of the study. From that one well, located north of Wapato (12N/19E-29G01), near the Yakima River, five out of nine of the seasonal samples were found to contain fecal streptococci, indicating that a bacterial problem may exist at this location. However, only one sample out of nine produced total coliform or *E. coli* colonies.

Geochemistry

A general classification of ground water can be obtained by determining the predominant cation (positive ion) and anion (negative ion) present in each sample (Hem, 1985). An ion is considered to be predominant if the concentration of that ion exceeds the others of the same charge by 10 percent or more. The major cations in water typically are calcium, magnesium, potassium, and sodium; the major anions in water typically are bicarbonate, carbonate, chloride, nitrate, and sulfate. The percentages of the ions in the analysis of each sample collected from the Toppenish Creek Basin during the intensive sampling phase are listed in table 10. Graphical representations of the ion percentages are presented in figures 7 and 8.

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program*

[All values are in micrograms per liter; <, less than; --, no data]

Local well number	Date	2,4-D, total	Ala-chlor, total recov-erable	Aldi-carb water, whole, total recov-erable	Atra-zine water, unfil-tered, recov-erable	Butyl-ate water, whole, recov-erable	3-Hydrx carbo-furan water, whole, total recov-erable	Carboxin water, whole, recov-erable
10N/17E-29A01	08-06-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/18E-02N01	08-06-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/18E-02Q01	03-20-91	<0.01	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
	09-08-92	<0.01	--	--	--	--	--	--
10N/18E-02R01	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/18E-04C01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/18E-04Q01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/18E-06R04	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/18E-15A01	03-19-91	<0.01	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/18E-15H01	03-19-91	<0.01	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/18E-36A01	03-19-91	--	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/19E-01J01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/19E-03A01	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/19E-05L01	08-05-92	--	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
	09-08-92	<0.01	--	--	--	--	--	--
10N/19E-07R01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/19E-08A01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/19E-21B01	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/19E-21K01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/19E-21M01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Chlor-pyrifos, total recov-erable	Di-sulfoton, total	Di-azinon, total	Dicamba (med-iben) (ban-vel d), total	Endo-sulfan, total	Guthion, total	Metho-myl, total
10N/17E-29A01	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/18E-02N01	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/18E-02Q01	03-20-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
	09-08-92	--	--	--	<0.01	--	--	--
10N/18E-02R01	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/18E-04C01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/18E-04Q01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/18E-06R04	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/18E-15A01	03-19-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/18E-15H01	03-19-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/18E-36A01	03-19-91	<0.01	<0.01	<0.01	--	<0.01	--	<0.5
	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/19E-01J01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/19E-03A01	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/19E-05L01	08-05-92	<0.01	<0.01	<0.01	--	<0.01	<0.1	<0.5
	09-08-92	--	--	--	<0.01	--	--	--
10N/19E-07R01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/19E-08A01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/19E-21B01	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/19E-21K01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/19E-21M01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Metolachlor water, whole, total recoverable	Metribuzin water, whole, total recoverable	Oxyamyl water, whole, total recoverable	Parathion, total	Picloram (tordon) (amdon), total	Propham, total	Terbacil water, whole, recoverable
10N/17E-29A01	08-06-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/18E-02N01	08-06-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/18E-02Q01	03-20-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	09-08-92	--	--	--	--	<0.01	--	--
10N/18E-02R01	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/18E-04C01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/18E-04Q01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/18E-06R04	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/18E-15A01	03-19-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/18E-15H01	03-19-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/18E-36A01	03-19-91	<0.2	<0.1	<0.5	<0.01	--	<0.5	<0.2
	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/19E-01J01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/19E-03A01	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/19E-05L01	08-05-92	<0.2	<0.1	<0.5	<0.01	--	<0.5	<0.2
	09-08-92	--	--	--	--	<0.01	--	--
10N/19E-07R01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/19E-08A01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/19E-21B01	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/19E-21K01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/19E-21M01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	2,4-D, total	Alachlor, total recoverable	Aldicarb water, whole, total recoverable	Atrazine water, unfiltered, recoverable	Butylate water, whole, recoverable	3-Hydrx carbofuran water, whole, total recoverable	Carboxin water, whole, recoverable
10N/19E-25B02	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/19E-25H02	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/19E-25H03	03-21-91	<0.01	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-01P01	08-06-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-06N02	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-07P01	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-09P01	08-06-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-17F01	08-06-92	--	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
	09-08-92	<0.01	--	--	--	--	--	--
10N/20E-17H01	08-06-92	--	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
	09-08-92	<0.01	--	--	--	--	--	--
10N/20E-17P01	08-06-92	<0.01	<0.1	--	<0.1	<0.1	--	<0.2
10N/20E-19J01	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-20K01	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-20M01	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-20P01	08-06-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-21B01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-21G01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-21G02	03-19-91	<0.01	<0.2	--	<0.1	<0.1	--	<0.2
	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-21J01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/20E-28H02	03-19-91	<0.01	<0.2	--	<0.1	<0.1	--	<0.2
	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Chlor-pyrifos, total recov-erable	Di-sulfoton, total	Di-azinon, total	Dicamba (med-iben) (ban-vel d), total	Endo-sulfan, total	Guthion, total	Metho-myl, total
10N/19E-25B02	08-05-92	<0.01	<0.01	0.01	<0.01	<0.01	<0.1	<0.5
10N/19E-25H02	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/19E-25H03	03-21-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-01P01	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-06N02	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-07P01	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-09P01	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-17F01	08-06-92	<0.01	<0.01	<0.01	--	<0.01	<0.1	<0.5
	09-08-92	--	--	--	<0.01	--	--	--
10N/20E-17H01	08-06-92	<0.01	<0.01	<0.01	--	<0.01	<0.1	<0.5
	09-08-92	--	--	--	<0.01	--	--	--
10N/20E-17P01	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	--
10N/20E-19J01	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-20K01	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-20M01	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	0.1	<0.5
10N/20E-20P01	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-21B01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-21G01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-21G02	03-19-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-21J01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/20E-28H02	03-19-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Metolachlor water, whole, total recoverable	Metribuzin water, whole, total recoverable	Oxyamyl water, whole, total recoverable	Parathion, total	Picloram (tordon) (amdon), total	Propham, total	Terbacil water, whole, recoverable
10N/19E-25B02	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/19E-25H02	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/19E-25H03	03-21-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-01P01	08-06-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-06N02	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-07P01	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-09P01	08-06-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-17F01	08-06-92	<0.2	<0.1	<0.5	<0.01	--	<0.5	<0.2
	09-08-92	--	--	--	--	<0.01	--	--
10N/20E-17H01	08-06-92	<0.2	<0.1	<0.5	<0.01	--	<0.5	<0.2
	09-08-92	--	--	--	--	<0.01	--	--
10N/20E-17P01	08-06-92	<0.2	<0.1	--	<0.01	<0.01	--	<0.2
10N/20E-19J01	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-20K01	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-20M01	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-20P01	08-06-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-21B01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-21G01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-21G02	03-19-91	<0.2	<0.1	--	<0.01	<0.01	<0.5	<0.2
	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-21J01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/20E-28H02	03-19-91	<0.2	<0.1	--	<0.01	<0.01	<0.5	<0.2
	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	2,4-D, total	Ala-chlor, total recov-erable	Aldi-carb water, whole, total recov-erable	Atra-zine water, unfil-tered, recov-erable	Butyl-ate water, whole, recov-erable	3-Hydrx carbo-furan water, whole, total recov-erable	Carboxin water, whole, recov-erable
10N/20E-29E01	03-21-91	<0.01	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
10N/21E-33B02	08-07-92	--	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
	09-08-92	<0.01	--	--	--	--	--	--
11N/16E-25N01	08-07-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/16E-35J01	08-07-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/18E-10C01	03-21-91	<0.01	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-06-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/18E-10J01	08-06-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/18E-22D01	03-20-91	<0.01	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-06-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/18E-22R01	08-06-92	--	<0.1	<0.5	0.1	<0.1	<0.5	<0.2
	09-09-92	<0.01	--	--	--	--	--	--
11N/18E-22R02	03-20-91	<0.01	<0.2	<0.5	0.1	<0.1	<0.5	<0.2
	08-06-92	<0.01	<0.1	<0.5	0.1	<0.1	<0.5	<0.2
11N/18E-26P01	08-07-92	--	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
	09-09-92	<0.01	--	--	--	--	--	--
11N/18E-27N01	03-20-91	<0.01	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-06-92	<0.01	<0.1	--	<0.1	<0.1	--	<0.2
11N/18E-27R02	03-20-91	<0.01	<0.2	--	<0.1	<0.1	--	<0.2
	08-06-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/18E-29N01	08-06-92	--	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
	09-09-92	<0.01	--	--	--	--	--	--
11N/18E-31A01	03-19-91	--	--	--	--	--	--	--
	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/18E-36R01	08-05-92	--	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
	09-09-92	<0.01	--	--	--	--	--	--

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Chlor-pyrifos, total recov-erable	Di-sulfoton, total	Di-azinon, total	Dicamba (med-iben) (ban-vel d), total	Endo-sulfan, total	Guthion, total	Metho-myl, total
10N/20E-29E01	03-21-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
10N/21E-33B02	08-07-92	<0.01	<0.01	<0.01	--	<0.01	<0.1	<0.5
	09-08-92	--	--	--	<0.01	--	--	--
11N/16E-25N01	08-07-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/16E-35J01	08-07-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/18E-10C01	03-21-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-06-92	<0.01	<0.01	0.01	<0.01	<0.01	<0.1	<0.5
11N/18E-10J01	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/18E-22D01	03-20-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/18E-22R01	08-06-92	<0.01	<0.01	<0.01	--	<0.01	<0.1	<0.5
	09-09-92	--	--	--	<0.01	--	--	--
11N/18E-22R02	03-20-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/18E-26P01	08-07-92	<0.01	<0.01	<0.01	--	<0.01	<0.1	<0.5
	09-09-92	--	--	--	<0.01	--	--	--
11N/18E-27N01	03-20-91	<0.01	<0.01	<0.01	0.01	<0.01	--	<0.5
	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	--
11N/18E-27R02	03-20-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-06-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/18E-29N01	08-06-92	<0.01	<0.01	<0.01	--	<0.01	<0.1	<0.5
	09-09-92	--	--	--	<0.01	--	--	--
11N/18E-31A01	03-19-91	--	--	--	--	--	--	--
	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/18E-36R01	08-05-92	<0.01	<0.01	<0.01	--	<0.01	<0.1	<0.5
	09-09-92	--	--	--	<0.01	--	--	--

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Metolachlor water, whole, total recoverable	Metribuzin water, whole, total recoverable	Oxyamyl water, whole, total recoverable	Parathion, total	Picloram (tordon) (amdon), total	Propham, total	Terbacil water, whole, recoverable
10N/20E-29E01	03-21-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
10N/21E-33B02	08-07-92	<0.2	<0.1	<0.5	<0.01	--	<0.5	<0.2
	09-08-92	--	--	--	--	<0.01	--	--
11N/16E-25N01	08-07-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/16E-35J01	08-07-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/18E-10C01	03-21-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-06-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/18E-10J01	08-06-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/18E-22D01	03-20-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-06-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/18E-22R01	08-06-92	<0.2	<0.1	<0.5	<0.01	--	<0.5	<0.2
	09-09-92	--	--	--	--	<0.01	--	--
11N/18E-22R02	03-20-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-06-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/18E-26P01	08-07-92	<0.2	<0.1	<0.5	<0.01	--	<0.5	<0.2
	09-09-92	--	--	--	--	<0.01	--	--
11N/18E-27N01	03-20-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-06-92	<0.2	<0.1	--	<0.01	<0.01	--	<0.2
11N/18E-27R02	03-20-91	<0.2	<0.1	--	<0.01	<0.01	<0.5	<0.2
	08-06-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/18E-29N01	08-06-92	<0.2	<0.1	<0.5	<0.01	--	<0.5	<0.2
	09-09-92	--	--	--	--	<0.01	--	--
11N/18E-31A01	03-19-91	--	--	--	--	--	--	--
	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/18E-36R01	08-05-92	<0.2	<0.1	<0.5	<0.01	--	<0.5	<0.2
	09-09-92	--	--	--	--	<0.01	--	--

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	2,4-D, total	Alachlor, total recoverable	Aldicarb water, whole, total recoverable	Atrazine water, unfiltered, recoverable	Butylate water, whole, recoverable	3-Hydrx carbofuran water, whole, total recoverable	Carboxin water, whole, recoverable
11N/19E-17N01	08-04-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/19E-23Q03	08-03-92	<0.01	<0.1	<0.5	0.1	<0.1	<0.5	<0.2
11N/19E-28A01	08-03-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/19E-29N01	03-19-91	<0.01	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-03-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/19E-35A02	08-03-92	<0.01	<0.1	<0.5	0.2	<0.1	<0.5	<0.2
11N/19E-36P01	08-05-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
11N/20E-33N04	08-07-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2
12N/19E-29G01	03-21-91	<0.01	<0.2	<0.5	<0.1	<0.1	<0.5	<0.2
	08-07-92	<0.01	<0.1	<0.5	<0.1	<0.1	<0.5	<0.2

Local well number	Date	Chlorpyrifos, total recoverable	Disulfoton, total	Diazinon, total	Dicamba (mediben) (ban vel d), total	Endosulfan, total	Guthion, total	Methomyl, total
11N/19E-17N01	08-04-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/19E-23Q03	08-03-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/19E-28A01	08-03-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/19E-29N01	03-19-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-03-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/19E-35A02	08-03-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/19E-36P01	08-05-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
11N/20E-33N04	08-07-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5
12N/19E-29G01	03-21-91	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.5
	08-07-92	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.5

Table 9.--*Concentrations of selected pesticides in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Date	Metolachlor water, whole, total recoverable	Metribuzin water, whole, total recoverable	Oxyamyl water, whole, total recoverable	Parathion, total	Picloram (tordon) (amdon), total	Propham, total	Terbacil water, whole, recoverable
11N/19E-17N01	08-04-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/19E-23Q03	08-03-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/19E-28A01	08-03-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/19E-29N01	03-19-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-03-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/19E-35A02	08-03-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/19E-36P01	08-05-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
11N/20E-33N04	08-07-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
12N/19E-29G01	03-21-91	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2
	08-07-92	<0.2	<0.1	<0.5	<0.01	<0.01	<0.5	<0.2

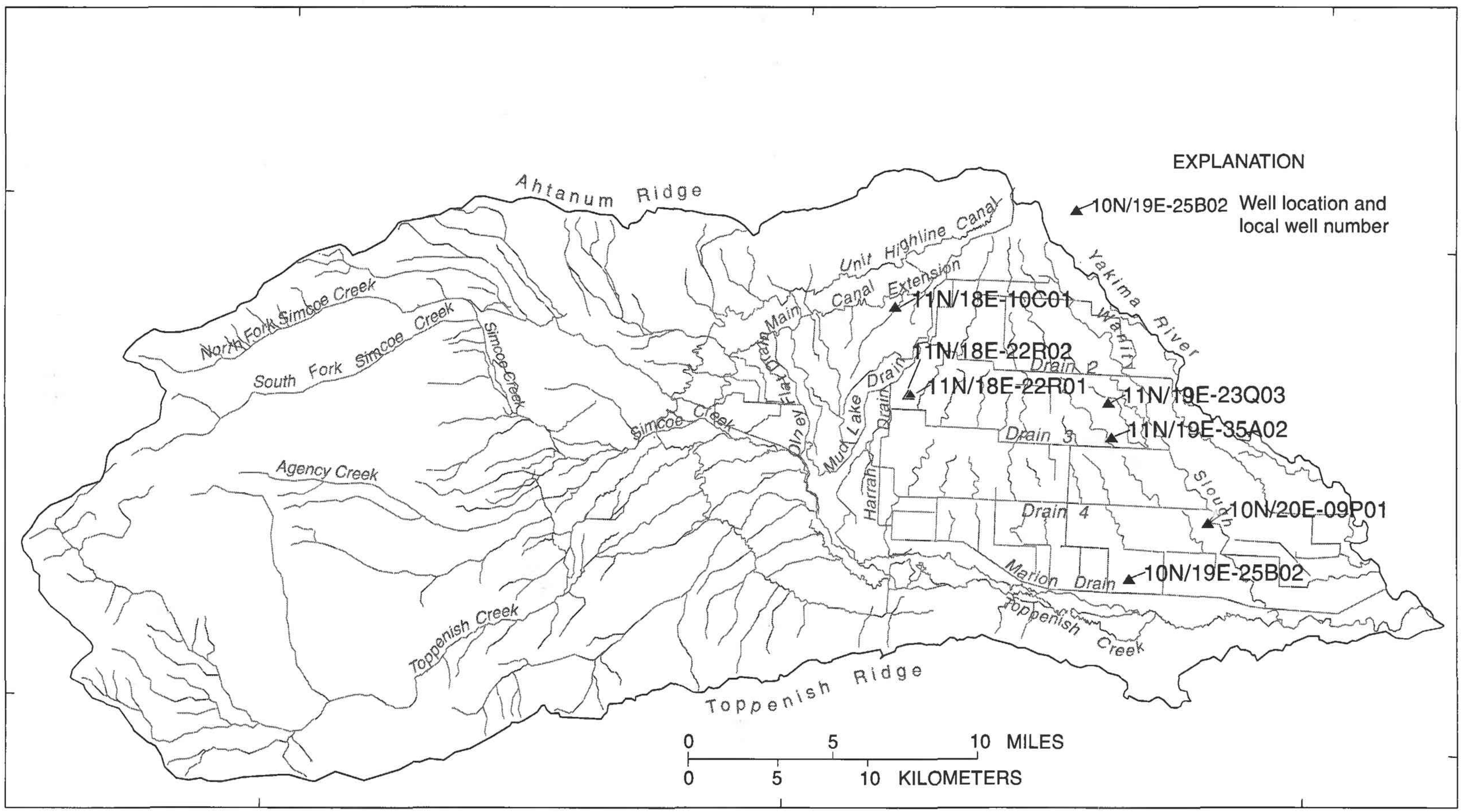

Figure 6. Locations of wells in which pesticides were detected, 1989.

Table 10.--*Major ions as a percentage of total cation and anion milliequivalents in ground-water samples collected during the intensive sampling program*

[Bas, basalt; Yvf, young valley fill; Ovf, old valley fill]

Local well number	Well depth, in feet	Major aquifer unit	Cations Na	Cations K	Cations Mg	Cations Ca	Anions Cl	Anions SO_4	Anions HCO_3	Anions NO_3
10N/17E-29A01	74	Bas	13	1	45	40	6	8	76	8
10N/18E-02N01	41	Yvf	19	3	30	48	5	8	78	9
10N/18E-02Q01	38	Yvf	18	3	31	49	5	9	74	11
10N/18E-02R01	60	Yvf	21	3	28	47	5	8	77	10
10N/18E-04C01	76	Yvf	21	3	32	44	3	4	90	3
10N/18E-04Q01	71	Yvf	28	3	31	38	5	8	81	6
10N/18E-06R04	80	Yvf	20	2	35	43	7	20	71	3
10N/18E-15A01	58	Yvf	26	3	27	45	5	7	81	7
10N/18E-15H01	61	Yvf	21	2	29	48	6	10	75	9
10N/18E-36A01	104	Yvf	9	1	35	55	16	23	56	4
10N/19E-01J021	62	Yvf	15	2	31	51	6	9	72	12
10N/19E-03A01	42	Ovf	15	3	31	50	5	8	78	8
10N/19E-05L01	62	Yvf	15	3	30	52	7	9	76	8
10N/19E-07R01	61	Yvf	20	3	25	53	5	6	82	6
10N19E-08A01	50	Yvf	16	3	29	53	6	7	80	8
10N/19E-21B01	50	Yvf	18	2	26	53	4	6	81	8
10N/19E-21K01	62	Yvf	18	2	28	52	6	7	79	9
10N/19E-21M01	65	Yvf	20	2	27	51	5	7	80	8
10N/19E-25B02	62	Ovf	18	2	26	53	4	7	79	10
10N/19E-25H02	62	Yvf	19	2	28	51	4	7	81	8
10N/19E-25H03	56	Ovf	21	2	26	50	3	5	85	7
10N/20E-01P01	180	Ovf	16	2	30	52	5	8	84	4
10N/20E-06N02	36	Yvf	15	3	32	51	6	8	74	12
10N/20E-07P01	62	Yvf	15	3	31	52	5	7	78	10
10N/20E-09P01	57	Yvf	17	2	30	51	5	6	80	8
10N/20E-17F01	62	Ovf	15	2	31	51	5	9	76	10
10N/20E-17H01	49	Yvf	16	2	32	50	5	8	77	10
10N/20E-17P01	56	Ovf	16	2	31	50	4	9	77	10
10N/20E-19J01	60	Yvf	16	2	30	52	4	7	80	9
10N/20E-20K01	60	Yvf	15	2	31	52	5	8	79	9
10N/20E-20M01	60	Yvf	15	2	30	53	5	8	79	8
10N/20E-20P01	60	Yvf	14	2	29	54	4	8	79	8
10N/20E-21B01	60	Ovf	12	2	34	52	6	8	77	8
10N/20E-21G01	60	Yvf	12	2	34	53	5	8	76	10
10N/20E-21G02	55	Yvf	13	2	33	52	5	9	75	11
10N/20E-21J01	23	Yvf	16	2	35	47	5	8	76	10
10N/20E-28H02	57	Yvf	14	2	32	51	5	8	75	11
10N/20E-29E01	50	Ovf	20	2	27	50	5	7	79	9
10N/21E-33B02	51	Yvf	22	3	31	45	7	8	78	7
11N/16E-25N01	72	Yvf	16	1	36	47	8	8	80	4
11N/16E-35J01	220	Yvf	17	2	38	42	10	12	71	6
11N/18E-10C01	136	Yvf	23	2	29	46	18	12	33	38
11N/18E-10J01	200	Yvf	34	1	28	36	4	7	83	6
11N/18E-22D01	60	Yvf	28	2	25	45	5	7	79	8
11N/18E-22R01	49	Yvf	17	3	26	54	6	9	76	9
11N/18E-22R02	58	Ovf	19	3	26	52	5	9	76	10
11N/18E-26P01	40	Yvf	13	2	27	57	6	8	76	10
11N/18E-27N01	64	Yvf	20	3	27	50	7	9	72	11
11N/18E-27R02	38	Yvf	17	3	27	53	6	9	77	9

Table 10.--*Major ions as a percentage of total cation and anion milliequivalents in ground-water samples collected during the intensive sampling program--Continued*

Local well number	Well depth, in feet	Major aquifer unit	Cations				Anions			
			Na	K	Mg	Ca	Cl	SO_4	HCO_3	NO_3
11N/18E-29N01	78	Yvf	26	2	31	41	5	8	82	4
11N/18E-31A01	100	Yvf	16	2	36	46	4	12	77	7
11N/18E-36R01	52	Yvf	17	3	29	50	9	7	79	5
11N/19E-17N01	40	Yvf	14	3	34	49	5	7	81	6
11N/19E-23Q03	58	Yvf	18	3	30	50	6	7	81	6
11N/19E-28A01	57	Ovf	15	3	30	52	5	11	68	16
11N/19E-29N01	40	Yvf	16	3	33	49	5	7	80	7
11N/19E-35A02	51	Yvf	15	2	32	51	6	7	76	10
11N/19E-36P01	52	Yvf	16	3	31	50	6	9	71	13
11N/20E-33N04	50	Yvf	16	2	30	51	7	8	72	13
12N/19E-29G01	55	Bas	39	3	26	32	6	15	79	0

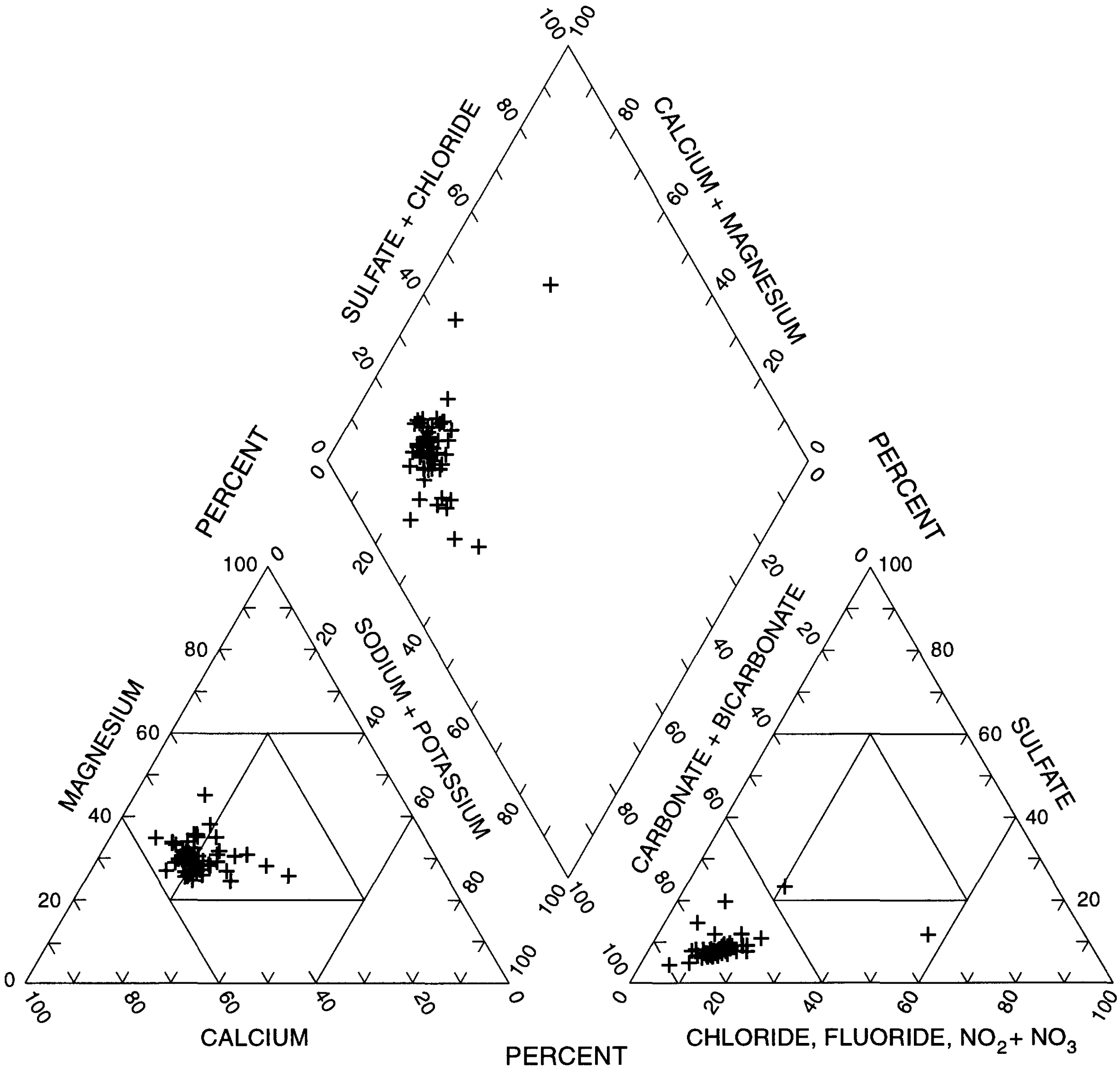

Figure 7. Trilinear diagram showing percentages of major ions in 60 ground-water samples collected during the intensive sampling phase, Toppenish Creek Basin, Washington, 1989.

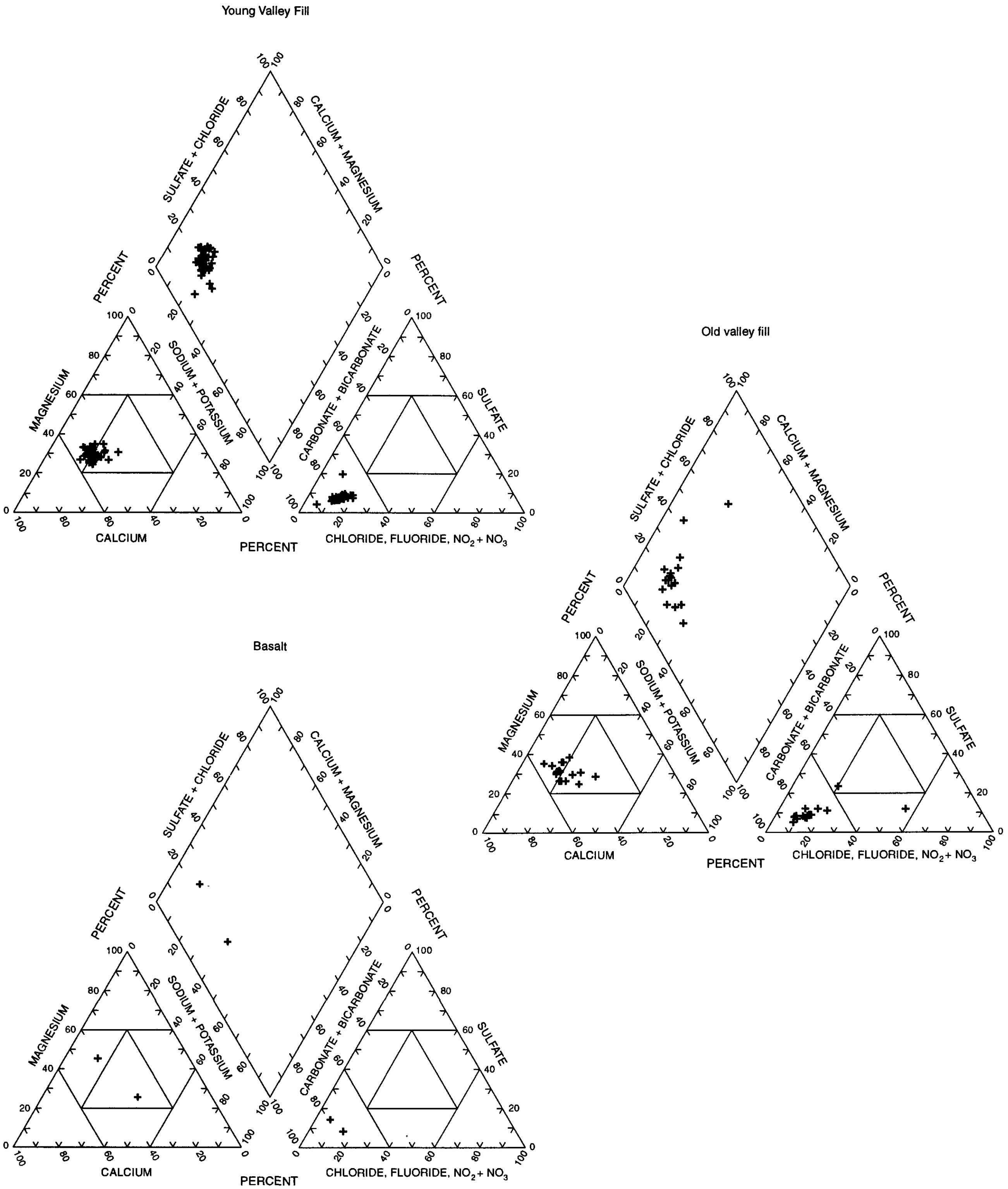

Figure 8. Trilinear diagrams showing percentages of major ions in ground-water samples, by aquifer unit, Toppenish Creek Basin, 1989.

Calcium was the predominant cation in most of the water samples collected during the intensive sampling program. In a few samples, magnesium and sodium were present at almost the same percentage as calcium. The predominant anion in most of the samples was bicarbonate, with one exception: the sample contained a high percentage (38 percent) of nitrate-nitrogen. The source of the nitrate is not known.

Turney (1986) found that calcium/magnesium-bicarbonate water was the most common water type from the unconsolidated aquifers in the lower Yakima River Basin, which includes the Toppenish Creek Basin. Ground water from the basalt aquifers was of the sodium-bicarbonate type. Data for the present study indicate that water from the young and old valley fills is of the calcium/magnesium-bicarbonate type. Analyses of water from two wells tapping the basalt aquifer indicate one is a calcium/magnesium-bicarbonate water type and the other is a sodium-bicarbonate water type. The wells tapping the basalt aquifer with the calcium/magnesium-bicarbonate water type are located in the southwest corner of the basin's agricultural area (township 10N, range 17E), and the high percentage of calcium and magnesium may be due to water percolating from overlying unconsolidated material.

Hardness

Hardness was determined for 15 wells in the spring of 1991 and for 60 wells in the summer of 1991 (the 15 wells sampled in the spring plus 45 additional wells) during the intensive sampling phase. The hardness of the samples ranged from moderately hard to very hard, using a classification system from Hem (1985). The number of wells in each hardness class are shown in the following table.

The primary consequences of high hardness values for domestic water use are decreased amounts of lather from soaps and deposition of residue and scale on cooking utensils and water heaters. However, Hem (1985) reports that several studies have correlated hard water with decreased incidences of heart disease.

Nitrogen

Nitrate concentrations from wells sampled during the synoptic phase ranged from less than 0.1 mg/L to 23.0 mg/L (Appendix 1); the median nitrate concentration was 1.2 mg/L. Nitrate concentrations in two wells (11.0 mg/L in 11N/18E-27R01 and 23.0 mg/L in 11N/18E-10C01; Payne and Sumioka, 1994) exceeded the USEPA drinking water criterion of 10 mg/L. Well 11N/18E-27R01 is an irrigation well at Harrah, Wash., and well 11N/18E-10C01 is a domestic well located about 4 miles north of Harrah and about 7 miles west of Wapato, Wash. Land use in the immediate vicinity of the domestic well is primarily dryland pasture. Nitrate concentrations from wells within 1 mile of well 11N/18E-10C01 were all less than 5 mg/L, suggesting that the high nitrate concentration is a localized condition.

An arbitrary classification of nitrate concentrations was used by Turney (1986) in the study of ground water in southeastern and south-central Washington. Under this system, 248 of 487 wells sampled during the synoptic phase of this study had water with moderate nitrate concentrations (between 1 mg/L and 5 mg/L). Twenty-four of 487 wells (about 5 percent) had large nitrate concentrations (between 5 mg/L and 10 mg/L). Only two wells had nitrate concentrations greater than 10 mg/L (Payne and Sumioka, 1994).

Class	Hardness range (in mg/L as $CaCO_3$)	Number of wells: Spring 1991 sampling (15 wells)	Number of wells: Summer 1991 sampling (60 wells)
Soft	0-60	0	0
Moderately hard	61-120	1	16
Hard	121-180	9	33
Very hard	greater than 180	5	11

In water samples collected during the seasonal sampling phase, nitrate concentrations increased slightly from about mid-March to mid-May, in 1991, decreased during the summer and fall, and increased slightly from about November 1991 to mid-January 1992 (fig. 9). The early spring increase in 1991 (March-May) is likely due to fertilizer applied to most fields at the start of the growing season. The late fall increase is likely due to fertilizer applications following the growing season for some crops grown in the basin: grapes, potatoes, corn, and pasture (Small and Jameson, 1989). In most cases, the difference between the largest nitrate concentration and the smallest during the seasonal sampling phase was less than 5 mg/L, indicating that, even though the nitrate concentration in ground water is large (often greater than 5.0 mg/L), seasonal variations are small, and the differences in the nitrate concentrations may be due to natural variations in concentrations. The largest seasonal variation in nitrate concentration was observed in a shallow (55-foot) well finished in the basalt aquifer (12N/19E-29G1). From March 1991 to May 1991 concentrations ranged from less than 0.05 mg/L to 16 mg/L. In August 1992 (during the intensive sampling phase; table 7), the nitrate concentration in a sample from this well was 0.23 mg/L. For the remainder of the seasonal sampling, nitrate concentrations were less than 0.05 mg/L. Land use in the vicinity of this well is primarily orchard (apples and peaches), and nitrate concentrations probably reflect the agricultural activities in the immediate area.

Nitrate concentrations for the 60 wells sampled for the second round of intensive sampling (August 1991) ranged from 0.22 mg/L to 28 mg/L (table 7). In general, these results were consistent with the nitrate concentrations obtained during the synoptic and seasonal sampling phases (Payne and Sumioka, 1994; Appendix 1, this report; table 6, this report).

Water samples containing more than 5.0 mg/L of nitrate were obtained from wells located primarily east and south of Harrah, Wash. (plate 2), indicating that, in general, elevated nitrate concentrations (greater than 5.0 mg/L) are found in the discharge areas for the basin-wide flow system (the southern and eastern parts of the basin). Wittman and Armstrong (1989) reported that nitrate concentrations were higher in samples from shallow wells in areas where the Touchet Beds of Flint (1938) were present (central part of the basin) than from wells where the Touchet Beds were absent. Statistical analysis of the nitrate-concentration data (rank-sum test, Iman and Conover, 1983) indicated there was no significant difference in nitrate concentration between areas where the Touchet Beds are present and where they are not present (fig. 10). However, the number of wells sampled in areas where the Touchet Beds are present amounted to only about 10 percent of the number of wells sampled in areas where the Touchet Beds are not present. This difference in sample size may have affected the results of the statistical analysis. The largest nitrate concentrations in the basin (about 30 mg/L) were found in samples from a well finished in the Touchet Beds (11N/18E-10C01). Land use in the vicinity of this well is pasture; a source for the nitrate was not determined.

Land use in the vicinity of this well is mostly pasture, which requires about 100 lbs/acre of nitrate fertilizer per year (Small and Jameson, 1989). In addition, Small and Jameson (1989) state that there is only a small per acre loss of nitrogen from pasture. Farther upgradient (between 1 and 3 miles north, plate 5) nitrate-fertilizer application rates range from less than 100 lbs/acre/yr up to 200 lbs/acre/yr in parts of this area. In general, however, elevated nitrate concentrations in ground water cannot be attributed to any specific fertilizer-application rate in the basin. There appear to be generally higher concentrations in the southern and western portions of the agricultural area, particularly in the young valley fill (plate 3).

Nitrate concentration ranges, grouped by source (aquifer units and surface water), are presented in figure 11 and shown on plates 3-5. The highest median concentration was found in samples from wells finished in the young valley fill (2.4 mg/L, table 11), followed by the median concentration in samples from wells finished in the old valley fill (0.7 mg/L) and finally, the median concentration in samples from wells finished in basalt (<0.1 mg/L). Nitrate concentrations in samples of surface water were only slightly smaller than those on samples from the young valley fill.

A comparison of results from this study, particularly from the synoptic phase, with results from Fretwell (1979), shows that mean nitrate concentrations have increased from 1975 to 1989 (table 12). However, the maximum nitrate concentration from the young valley fill was greater in 1975 (20.0 mg/L) than in 1989 (11.0 mg/L).

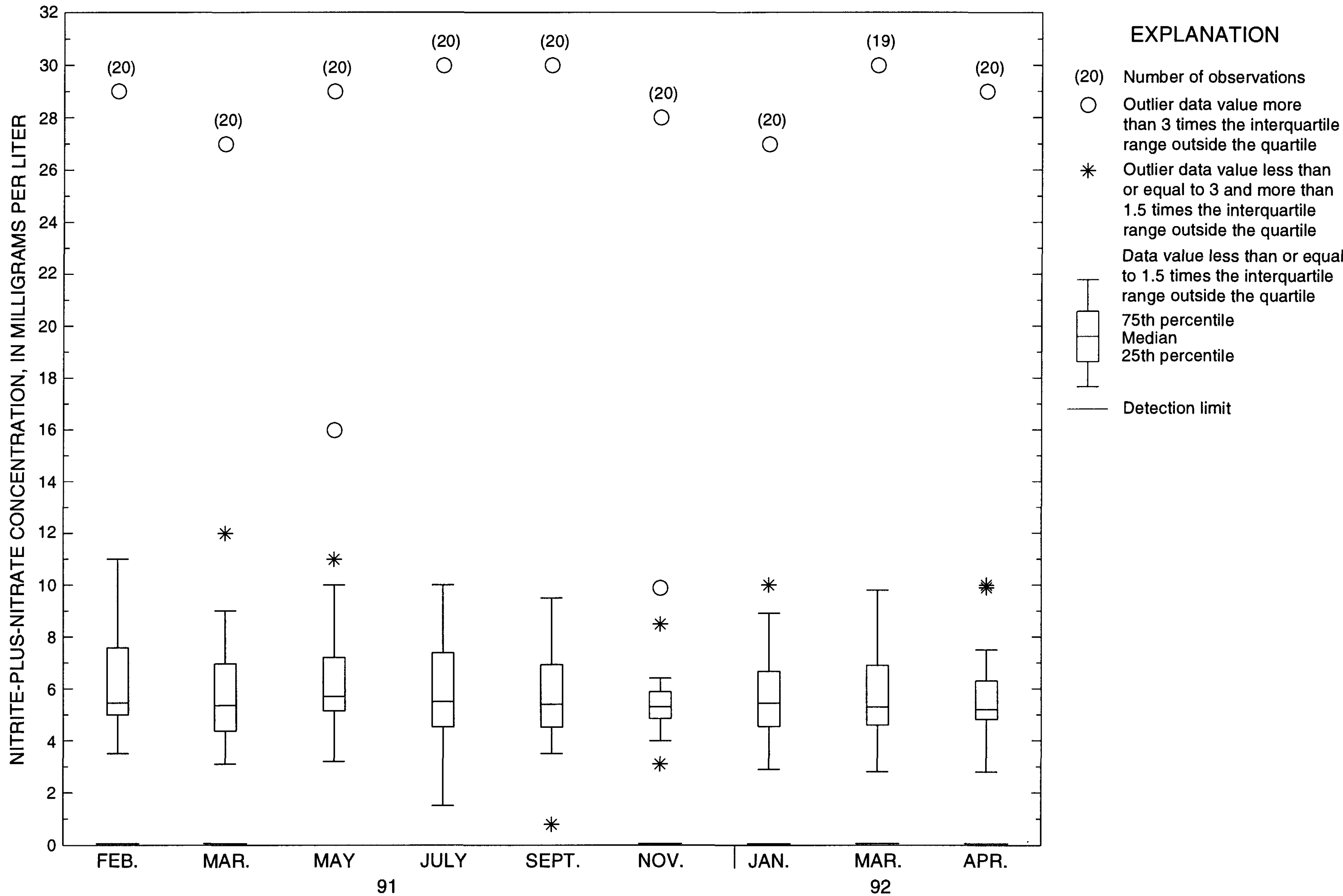

Figure 9. Seasonal variation in nitrite-plus-nitrate concentrations in ground water from the Toppenish Creek Basin, Washington,1989.

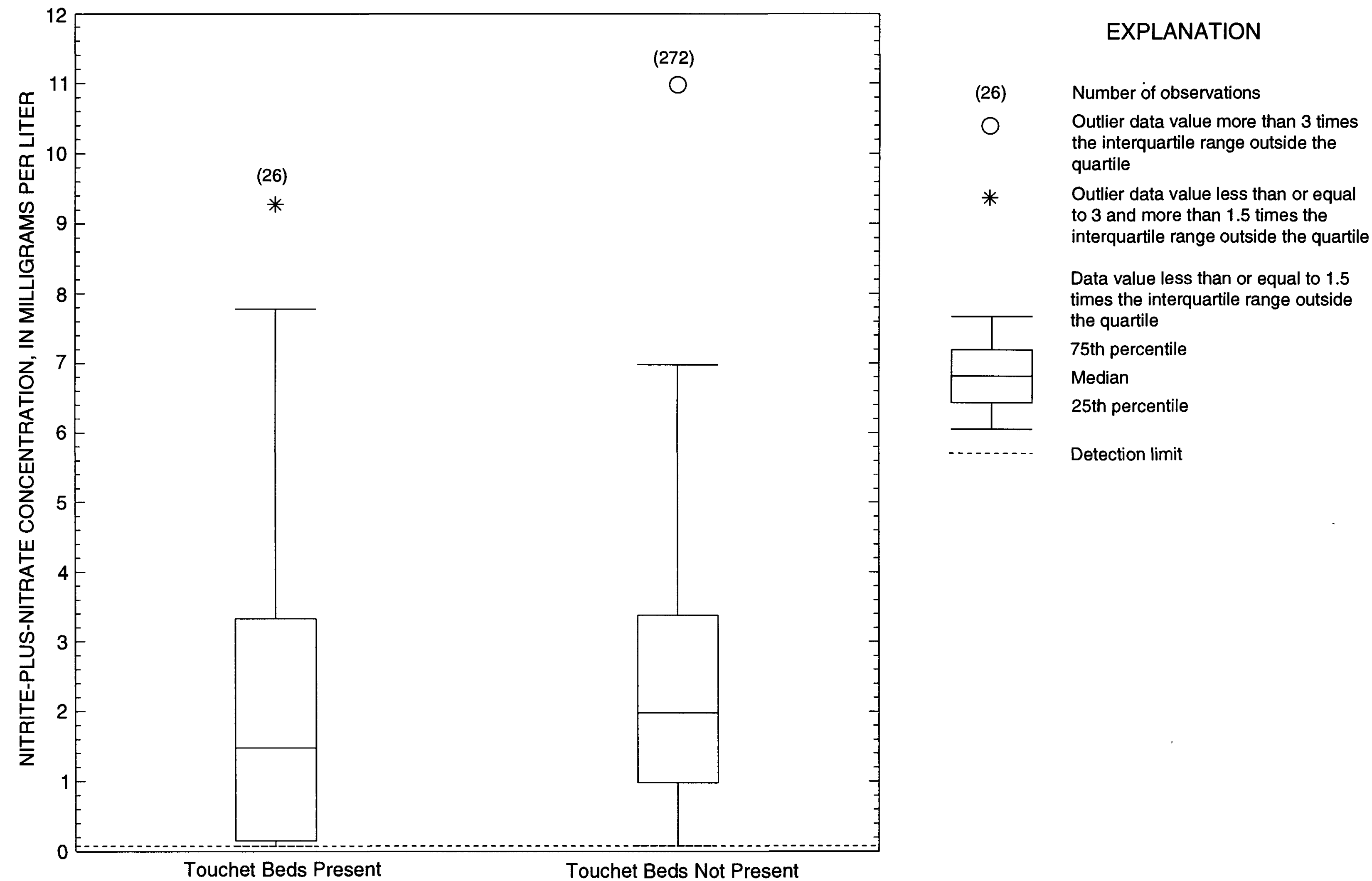

Figure 10. Nitrite-plus-nitrate concentrations in ground-water samples from wells where the Touchet Beds of Flint (1938) are and are not present,Toppenish Creek Basin, Washington, 1989.

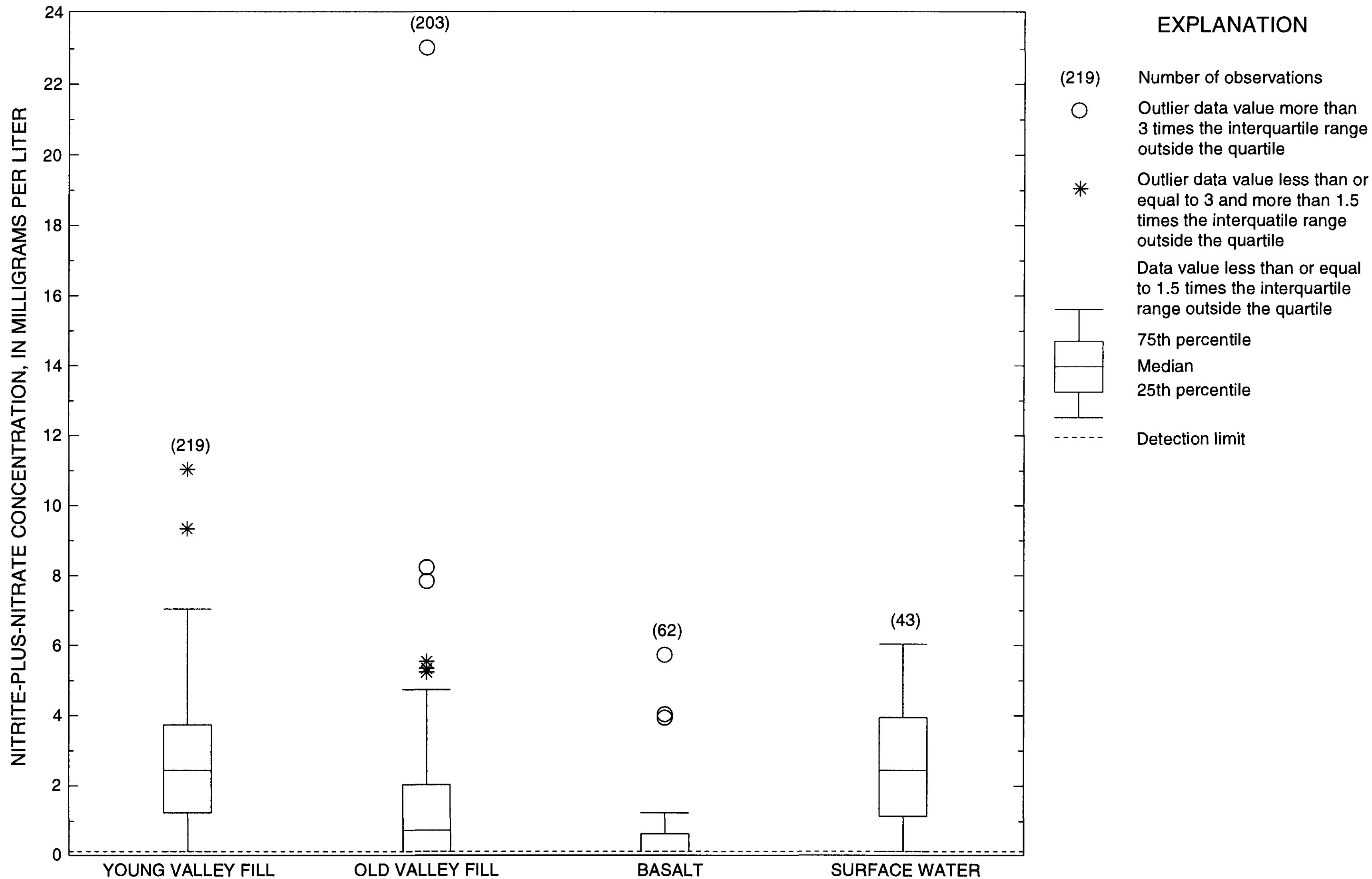

Figure 11. Nitrite-plus-nitrate concentrations in ground and surface water, Toppenish Creek Basin, Washington, 1989.

Table 11.--*Mean and median nitrate concentrations in ground-water and surface-water samples collected in the Toppenish Creek Basin, Washington, 1989*
[Values in milligrams per liter; <, less than]

	Source of water samples			
	Young valley fill (219 samples)	Old valley fill (203 samples)	Basalt (62 samples)	Surface-water (43 samples)
Mean	2.5	1.4	0.5	2.5
Median	2.4	0.7	<0.1	2.4

Table 12.--*Nitrate concentrations from Fretwell (1979) and from the present (1989) study*
[Number of samples in parentheses; all concentrations in milligrams per liter, as N; <, less than]

	1979	1989
Young Valley Fill		
Mean	2.5 (219)	1.9 (258)
Minimum	<0.1	0.0
Maximum	11.0	20.0
Old Valley Fill		
Mean	1.4 (203)	0.67 (20)
Minimum	<0.1	0.01
Maximum	23.0	4.8
Basalt		
Mean	0.49 (62)	0.2 (36)
Minimum	<0.1	0.0
Maximum	5.7	1.5

Ten wells sampled during the current study were also sampled by Fretwell in 1973-74 (Fretwell, 1979). With only one exception, nitrate concentrations found in this study were greater than or equal to the concentrations found in the earlier study, agreeing with the change in mean nitrate concentrations (table 12).

The one exception was the well at T10N/R20E-20K01; the nitrate concentration in 1973-74 was 4.7 mg/L, but in this study the nitrate concentration was 3.8 mg/L. Even though mean nitrate concentrations increased from 1975 to 1989, the time of sampling in relation to time of fertilizer application may account for the differences in concentration. Sampling in 1989 took place during the middle and latter parts of the growing season in the basin. Most of the sampling in 1973-74 took place in the fall (September through November), well after most crops were fertilized for the season (Small and Jameson, 1989).

SURFACE-WATER QUALITY

Concentrations of fecal bacteria in the irrigation drains and creeks in the basin during the synoptic phase of sampling did not indicate any pattern or any relation to agricultural activities in the basin. Fecal bacteria were detected at sites on Simcoe and Toppenish Creeks upstream of agricultural areas, as well as in all drains and creeks downgradient of the agricultural areas (Payne and Sumioka, 1994; Appendices 2-3).

Analyses of samples collected from irrigation drains and creeks in the basin indicate that the highest nitrate concentrations were found in Harrah Drain (6.0 mg/L, fig. 12). These drains receive water from the central part of the basin, and the nitrate concentrations reflect the agricultural activities there. Nitrate concentrations in Toppenish Creek and its tributaries were generally less than 2.0 mg/L. Marion Drain probably intercepts much of the nitrate-containing irrigation return flow before it reaches Toppenish Creek. However, one sample from Mud Lake Drain contained 3.6 mg/L of nitrate. This drain collects water from the western edge of the area most heavily used for agriculture, and this is reflected in the nitrate concentration.

SUMMARY

In general, ground-water quality in the Toppenish Creek Basin is good in relation to USEPA drinking water standards. Nitrate concentrations in samples from two wells and the mercury concentration in a sample from another well exceeded USEPA drinking water standards for these two constituents. Concentrations of dissolved solids and manganese in a sample from one well exceeded non-enforceable USEPA secondary drinking water standards. Pesticides were detected in samples from six wells: atrazine in four samples, diazinon in one, and disulfoton in another. The concentrations of these pesticides were below any applicable USEPA drinking water standards.

Bacteria, indicators of the sanitary quality of ground water, were detected in 64 of the 487 wells sampled during the synoptic phase of the study. Bacteria were also detected in samples from 9 of the 20 wells sampled during the seasonal sampling phase; however, they were detected in more than 2 samples in only 1 well. The bacteria detected during the study may have come from leaks in the plumbing system of the well or residence or improper well construction. These data indicate that fecal contamination may be a problem in some parts of the basin, but at the present time the contamination appears to be restricted to specific wells, not the aquifers as a whole.

Seasonal variations in nitrate concentrations for most of the basin consisted of an increase in the early spring, in response to the first fertilizer application of the growing season; a gradual decline during the summer; and a slight increase in the fall, most likely the result of a final fertilizer application for some crops (grapes, potatoes, corn, and pasture).

Small increases in mean nitrate concentrations from 1975 to 1989 were noted; however, time of sampling in relation to the growing season may also account for the difference in concentrations.

Geographically, wells producing water with elevated nitrate concentrations (greater than 5.0 mg/L) were located south and east of Harrah. There did not appear to be any geographic or geologic pattern associated with the occurrence of other constituents in ground water. Samples from irrigation drains and several streams in the area indicated that agricultural activities affected surface water to a greater extent than ground water.

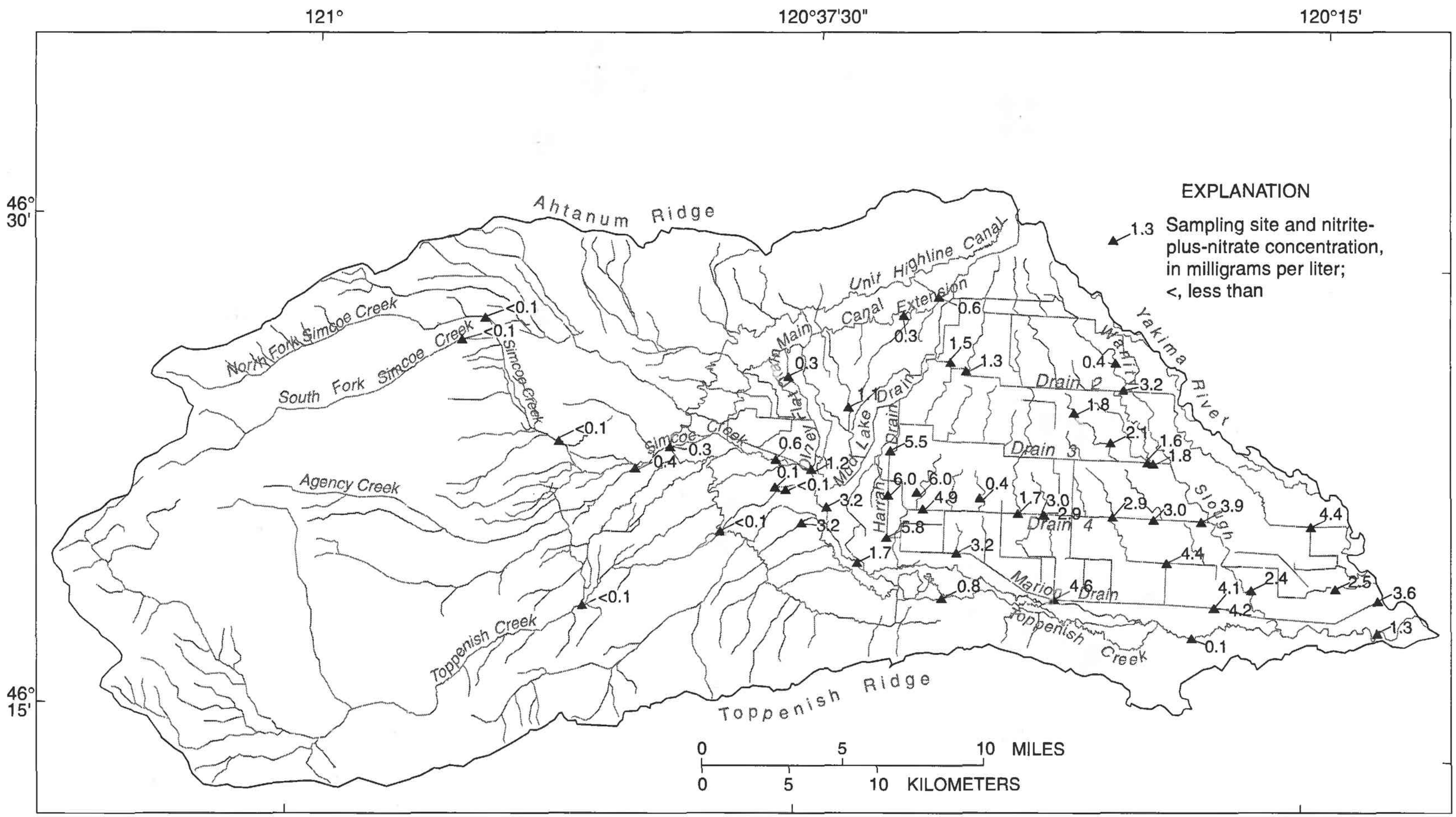

Figure 12. Nitrite-plus-nitrate concentrations at selected surface-water sites in the Toppenish Creek Basin, Washington, 1989.

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Appendix 1.--*Ground-water-quality data, July-September, 1989*

[Deg C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°Celsius; mg/L, milligrams per liter; cols./100 ml, colonies per 100 milliliters; <, less than; >, greater than; --, constituents not analyzed for; E, estimated number based on count of only part of the plate; K, number based on count outside of ideal range]

Local well number	Date	Temperature water (Deg C)	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, ammonia+ organic total (mg/L as N)	Nitrogen, NO_2 $+NO_3$ total (mg/L as N)	Coliform, fecal, (cols./ 100 ml)	Streptococci, fecal, (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
10N/16E-01C01	08-17-89	14.5	440	7.2	6.3	<0.010	0.30	1.90	<1	<1	<1
10N/16E-01D01	08-18-89	12.0	270	7.6	7.1	--	--	0.80	<1	<1	<1
10N/16E-01D02	08-17-89	14.5	430	7.3	6.8	--	--	1.30	<1	<1	<1
10N/16E-02D02	08-17-89	13.5	160	7.0	5.0	--	--	<0.10	<1	<1	<1
10N/16E-03N02	08-30-89	19.5	410	7.5	0.4	<0.010	<0.20	<0.10	<1	<1	<1
10N/16E-09J01	08-30-89	15.0	171	7.6	5.8	--	--	0.60	<1	<1	<1
10N/16E-10J01	08-22-89	16.0	310	7.9	1.8	--	--	<0.10	<1	<1	<1
10N/16E-11B01	09-26-89	13.5	224	7.7	2.2	--	--	0.40	<1	<1	<1
10N/16E-11C02	08-24-89	14.0	208	7.6	2.0	<0.010	<0.20	0.40	<1	<1	<1
10N/16E-11J03	08-21-89	12.5	148	7.6	5.2	--	--	0.10	<1	<1	<1
10N/16E-11K02	08-22-89	13.5	148	7.4	5.1	--	--	0.10	<1	E71	<1
10N/16E-11K03	08-22-89	13.5	145	7.7	5.9	--	--	0.10	<1	<1	<1
10N/16E-12B01	08-24-89	13.0	170	6.9	5.6	<0.010	<0.20	0.10	<1	8	<1
10N/16E-12M01	08-28-89	13.5	175	8.0	0.3	<0.010	<0.20	<0.10	<1	<1	<1
10N/16E-12N02	08-18-89	15.0	131	7.7	2.8	--	--	<0.10	<1	K2	<1
10N/16E-12P01	08-24-89	15.5	129	8.0	2.1	<0.010	<0.20	<0.10	<1	<1	<1
10N/16E-13D01	08-17-89	14.0	144	7.5	6.6	--	--	0.10	<1	<1	<1
	08-30-89	13.5	149	7.5	8.7	--	--	0.20	<1	<1	<1
10N/16E-13J01	08-25-89	13.0	168	6.9	7.9	--	--	1.60	<1	K1	<1
	08-30-89	12.5	163	6.6	5.9	--	--	1.50	<1	<1	<1
10N/16E-15M02	08-17-89	15.5	248	7.4	4.2	--	--	0.50	<1	11	<1
10N/16E-15N02	08-24-89	15.0	229	7.5	8.7	--	--	0.30	<1	<1	<1
10N/16E-20E01D1	08-24-89	16.0	270	7.7	5.9	--	--	0.20	<1	<1	<1
10N/16E-20F01	09-14-89	14.5	252	7.3	--	--	--	0.60	<1	<1	<1
10N/16E-21D01	08-23-89	14.0	840	7.3	6.9	--	--	0.40	<1	<1	<1
10N/16E-24F01	08-18-89	18.0	169	7.7	4.7	--	--	<0.10	<1	<1	<1
10N/16E-35F02	08-18-89	15.0	252	7.3	3.0	--	--	<0.10	<1	<1	<1
10N/17E-02E01	08-10-89	15.0	455	7.6	0.1	0.040	<0.20	<0.10	<1	<1	<1
10N/17E-02M02	08-09-89	14.5	648	6.8	2.4	--	--	2.00	<1	<1	<1
10N/17E-04F01	08-09-89	13.0	182	7.2	4.9	--	--	0.20	<1	<1	<1
10N/17E-04Q02	08-09-89	13.5	203	7.2	6.5	--	--	0.30	<1	<1	<1
10N/17E-05D01	08-29-89	--	190	7.8	0.3	--	--	<0.10	<1	K155	<1
10N/17E-05D02	08-30-89	14.5	170	7.9	0.7	<0.010	<0.20	<0.10	<1	<1	<1
10N/17E-05D03	08-29-89	13.0	188	7.6	3.6	--	--	0.20	<1	K36	<1
10N/17E-05E03	08-23-89	15.0	160	7.8	0.0	<0.010	0.30	0.20	<1	<1	<1
10N/17E-05E04	08-23-89	14.0	148	7.8	1.2	<0.010	0.40	0.10	<1	<1	<1
10N/17E-05L01	08-29-89	15.5	179	7.7	3.5	--	--	0.20	<1	K2	<1
10N/17E-05L02	08-17-89	12.5	178	6.7	8.2	--	--	0.70	<1	<1	<1
10N/17E-05L05	08-29-89	12.0	201	7.0	6.9	<0.010	<0.20	0.70	<1	<1	<1
10N/17E-05Q02	09-13-89	20.0	152	7.3	0.4	0.020	0.40	<0.10	<1	<1	<1
10N/17E-06H02	09-25-89	16.5	199	6.7	1.4	<0.010	<0.20	<0.10	<1	<1	<1
10N/17E-07A02	08-17-89	13.0	134	6.8	7.6	--	--	0.30	<1	<1	<1
10N/17E-07A03	08-17-89	13.0	134	6.8	8.2	--	--	0.30	<1	<1	<1
10N/17E-07H01	08-11-89	13.5	144	8.1	2.4	--	--	0.10	<1	<1	<1
10N/17E-07J02	08-30-89	--	180	6.8	8.3	--	--	0.70	<1	<1	<1

Appendix 1.--*Ground-water-quality data, July-September, 1989--Continued*

Local well number	Date	Temperature water (Deg C)	Specific conductance (μS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, ammonia+ organic total (mg/L as N)	Nitrogen, NO_2 $+NO_3$ total (mg/L as N)	Coliform, fecal, (cols./ 100 ml)	Streptococci, fecal, (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
10N/17E-07J03	08-30-89	12.5	164	6.8	6.0	--	--	0.70	<1	<1	<1
10N/17E-07J04	08-30-89	12.5	166	7.0	9.5	--	--	0.90	<1	K12	<1
10N/17E-07R01	08-18-89	13.0	155	7.1	6.9	--	--	0.40	<1	<1	<1
10N/17E-07R02	08-30-89	13.5	142	6.9	7.4	--	--	0.50	<1	<1	<1
10N/17E-08E01	08-11-89	13.5	165	6.8	7.2	--	--	0.70	<1	<1	<1
10N/17E-08L02	08-18-89	14.0	135	8.0	5.2	--	--	<0.10	<1	<1	<1
10N/17E-08N01	08-29-89	14.5	138	7.8	0.1	<0.010	<0.20	<0.10	<1	<1	<1
10N/17E-08N02	08-29-89	14.5	165	7.0	4.3	--	--	0.70	<1	<1	<1
10N/17E-08N03	08-29-89	20.0	134	7.8	1.5	<0.010	<0.20	0.10	<1	<1	<1
10N/17E-08N04	09-15-89	17.0	133	8.0	0.2	<0.010	<0.20	<0.10	<1	<1	<1
10N/17E-10D02	08-17-89	14.0	351	7.2	2.5	--	--	1.00	<1	<1	<1
10N/17E-10D03	08-25-89	14.0	260	7.2	3.8	--	--	0.30	<1	<1	<1
10N/17E-10J01	08-28-89	13.5	--	7.1	2.0	--	--	<0.10	<1	<1	<1
10N/17E-10R01	08-28-89	15.5	--	7.3	0.0	0.040	2.5	<0.10	<1	<1	<1
10N/17E-11B03	09-01-89	14.0	599	6.9	1.6	<0.010	<0.20	1.40	<1	K3	<1
10N/17E-11B04	09-11-89	13.0	360	7.0	0.9	<0.010	<0.20	0.80	<1	<1	<1
10N/17E-11B05	09-12-89	13.5	372	7.3	0.7	<0.010	0.40	0.30	<1	<1	<1
10N/17E-11C01	09-15-89	14.5	328	7.4	0.0	0.020	<0.20	<0.10	<1	<1	<1
10N/17E-11N01	08-30-89	16.0	271	7.3	0.0	0.020	<0.20	<0.10	<1	<1	<1
10N/17E-15M03	08-16-89	13.0	162	7.0	4.2	--	--	0.20	<1	<1	<1
10N/17E-15M04	09-11-89	15.0	180	7.6	--	--	--	<0.10	<1	K1	<1
10N/17E-17L01	08-11-89	16.0	152	7.1	5.3	--	--	0.40	<1	K4	<1
10N/17E-17N01	08-10-89	12.0	127	7.0	6.5	--	--	0.40	<1	<1	<1
10N/17E-18M01	09-01-89	12.5	134	7.1	6.8	<0.010	<0.20	0.30	<1	<1	<1
10N/17E-18M02	09-11-89	13.0	142	7.1	4.4	--	--	0.40	<1	<1	<1
10N/17E-18N01	09-27-89	12.5	136	6.9	6.6	--	--	0.50	<1	<1	<1
10N/17E-18N02	09-26-89	12.0	110	7.0	8.5	--	--	0.30	<1	<1	<1
10N/17E-18P01	08-11-89	12.5	126	6.9	7.2	--	--	0.40	<1	<1	<1
10N/17E-18R01	09-01-89	12.5	128	6.8	7.1	--	--	0.40	<1	<1	<1
10N/17E-19M01	09-13-89	15.0	168	7.4	5.6	<0.010	<0.20	1.20	<1	<1	<1
10N/17E-20A02	08-11-89	13.0	157	7.4	2.3	--	--	<0.10	<1	<1	<1
10N/17E-20A03	08-25-89	14.0	130	7.6	2.0	<0.010	<0.20	<0.10	<1	<1	<1
10N/17E-20A04	09-13-89	12.5	148	7.3	1.2	0.080	0.50	<0.10	<1	<1	<1
10N/17E-20A05	08-10-89	11.5	128	7.0	6.4	--	--	0.30	<1	<1	<1
10N/17E-20B01	09-12-89	11.5	112	6.8	7.1	--	--	0.20	<1	<1	<1
10N/17E-20E01	08-11-89	14.5	180	8.1	0.3	<0.010	<0.20	<0.10	<1	K2	<1
10N/17E-20R02	09-12-89	--	555	7.2	5.4	--	--	2.30	<1	<1	<1
10N/17E-21A01	08-25-89	15.5	156	7.7	0.1	0.020	<0.20	<0.10	<1	<1	<1
10N/17E-25C01	08-25-89	13.0	1,020	7.2	0.6	0.010	0.40	3.50	<1	<1	<1
10N/17E-26B01	09-15-89	19.5	381	7.2	0.0	0.030	<0.20	<0.10	<1	<1	<1
10N/17E-26J01	09-15-89	24.5	380	7.5	0.0	0.040	<0.20	<0.10	<1	<1	<1
10N/17E-27Q01	09-26-89	29.0	428	7.3	1.0	0.030	<0.20	<0.10	<1	<1	<1
10N/17E-28B01	09-15-89	24.5	390	7.8	--	--	--	<0.10	<1	<1	<1
10N/17E-29A01	08-31-89	16.0	335	7.3	4.3	--	--	3.90	<1	K4	<1
10N/17E-29A02	09-12-89	16.5	360	7.4	8.0	--	--	4.00	<1	K1	<1
10N/17E-29C01	09-12-89	20.0	320	7.4	0.2	0.020	<0.20	0.30	K30	K38	K34
10N/17E-35B02	09-14-89	24.5	415	7.6	--	--	--	<0.10	<1	<1	<1
10N/17E-36R01	08-23-89	23.5	350	7.8	0.1	0.040	<0.20	<0.10	<1	<1	<1
10N/18E-01A02	07-19-89	15.0	289	7.2	1.4	0.110	2.0	1.50	<1	<1	<1
10N/18E-02N01	09-13-89	14.5	372	7.4	5.3	--	--	5.30	<1	K1	<1

Appendix 1.--*Ground-water-quality data, July-September, 1989--Continued*

Local well number	Date	Temperature water (Deg C)	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, ammonia+ organic total (mg/L as N)	Nitrogen, NO_2 $+NO_3$ total (mg/L as N)	Coliform, fecal, (cols./ 100 ml)	Streptococci, fecal, (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
10N/18E-02Q01	07-20-89	14.0	340	7.3	6.2	<0.010	4.3	5.10	<1	<1	<1
10N/18E-02P01	08-31-89	16.0	370	7.3	2.5	<0.010	<0.20	5.10	<1	<1	<1
10N/18E-02R01	08-31-89	14.5	340	7.4	6.7	--	--	4.30	<1	<1	<1
10N/18E-04C01	07-20-89	14.0	425	7.4	3.6	--	--	4.10	<1	<1	<1
10N/18E-04C02	08-25-89	13.0	501	7.1	2.3	<0.010	0.30	1.50	K2	K8	K2
10N/18E-04C03	08-25-89	13.5	502	7.1	2.3	--	--	1.30	K1	<1	<1
10N/18E-04G01	09-01-89	14.5	370	7.4	3.8	--	--	2.60	<1	<1	<1
10N/18E-04Q01	08-25-89	14.5	586	7.3	4.3	--	--	4.30	<1	<1	<1
10N/18E-06H02	07-27-89	16.0	650	7.1	0.0	0.140	0.30	<0.10	<1	<1	<1
10N/18E-06H03	08-31-89	15.5	478	7.4	3.0	--	--	1.50	<1	<1	<1
10N/18E-06N01D1	08-31-89	14.5	482	7.5	0.2	0.090	<0.20	<0.10	<1	<1	<1
10N/18E-06P03	08-25-89	15.5	400	7.6	0.0	0.050	0.50	<0.10	<1	<1	<1
10N/18E-06R04	07-20-89	13.5	835	7.0	2.3	--	--	5.00	<1	<1	<1
10N/18E-08C01	07-27-89	14.0	720	7.3	0.2	<0.010	<0.20	0.20	<1	<1	<1
10N/18E-08D02	07-27-89	16.0	492	7.6	0.0	0.030	<0.20	<0.10	<1	<1	<1
10N/18E-09M01	07-28-89	15.0	642	7.6	0.0	0.060	1.4	<0.10	<1	<1	<1
10N/18E-09N01	08-28-89	15.5	532	7.4	0.3	0.050	<0.20	<0.10	<1	<1	<1
10N/18E-12A02	09-27-89	14.5	283	7.1	6.5	--	--	2.60	<1	<1	<1
10N/18E-12C01	07-28-89	15.5	282	7.1	5.9	--	--	3.00	<1	<1	<1
10N/18E-15A01	07-21-89	15.5	410	7.3	7.9	--	--	5.60	<1	<1	<1
10N/18E-15H01	07-21-89	14.0	425	7.3	4.0	--	--	6.00	<1	<1	<1
10N/18E-15L01	09-01-89	15.0	860	7.5	0.0	<0.010	<0.20	<0.10	<1	K8	<1
10N/18E-15P01	09-01-89	15.5	469	7.5	0.0	0.050	<0.20	<0.10	<1	<1	<1
10N/18E-16E01	09-13-89	15.5	743	7.4	0.4	0.010	0.30	<0.10	<1	<1	<1
10N/18E-16M01	08-16-89	15.5	299	7.8	0.3	0.140	0.30	<0.10	<1	<1	<1
10N/18E-16N01	09-13-89	14.5	548	7.7	0.5	0.200	0.40	<0.10	<1	<1	<1
10N/18E-18H01	08-16-89	14.5	725	7.3	0.3	0.030	<0.20	<0.10	<1	<1	<1
10N/18E-24A01	08-09-89	14.5	330	7.3	4.6	--	--	3.40	<1	<1	<1
10N/18E-30E01	07-28-89	15.5	215	7.5	0.3	<0.010	<0.20	<0.10	<1	<1	<1
10N/18E-30E02	09-25-89	14.5	650	7.3	5.7	--	--	3.00	<1	<1	<1
10N/18E-31N01	09-26-89	22.5	363	7.8	--	0.020	<0.20	<0.10	<1	K48	<1
10N/18E-34C01	07-28-89	14.5	502	7.3	4.7	<0.010	<0.20	0.80	<1	<1	<1
10N/18E-34C02	07-28-89	15.5	410	7.3	5.2	--	--	0.70	<1	<1	<1
10N/18E-36A01	08-09-89	16.0	1,120	7.4	6.5	--	--	8.20	<1	<1	<1
10N/19E-01J01	07-17-89	15.0	287	7.0	6.3	--	--	4.50	<1	K800	<1
10N/19E-01J02	07-18-89	15.0	272	7.1	5.9	--	--	4.30	<1	<1	<1
10N/19E-03A01	07-18-89	14.5	290	7.1	6.3	--	--	4.30	<1	<1	<1
10N/19E-05L01	07-18-89	16.0	264	7.2	4.3	--	--	3.80	<1	K350	<1
10N/19E-06P01	07-26-89	15.0	295	7.1	4.4	--	--	1.80	<1	<1	<1
10N/19E-06P02	07-26-89	15.5	308	7.1	3.3	--	--	1.80	<1	<1	<1
10N/19E-06P03	08-08-89	15.5	262	7.0	5.4	--	--	1.70	<1	13	<1
10N/19E-07B01	09-13-89	15.5	262	7.1	4.8	--	--	1.90	<1	<1	<1
10N/19E-07B03	07-18-89	15.5	281	7.1	4.1	<0.010	0.20	2.20	<1	<1	<1
10N/19E-07C02	09-11-89	17.0	384	7.1	3.7	--	--	1.80	<1	50	<1
10N/19E-07L01	09-13-89	14.5	318	7.2	3.4	--	--	1.70	<1	<1	<1
10N/19E-07R01	09-13-89	14.5	305	7.7	4.2	--	--	3.20	<1	<1	<1
10N/19E-08A01	08-08-89	15.0	262	7.1	7.0	--	--	3.10	<1	<1	<1
10N/19E-08D01	07-19-89	14.5	278	7.2	7.7	0.010	<0.20	4.70	<1	<1	<1
10N/19E-08N02	09-13-89	15.5	299	7.7	4.4	--	--	2.70	<1	<1	<1

Appendix 1.--*Ground-water-quality data, July-September, 1989--Continued*

Local well number	Date	Temperature water (Deg C)	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, ammonia+ organic total (mg/L as N)	Nitrogen, NO_2 $+NO_3$ total (mg/L as N)	Coliform, fecal, (cols./ 100 ml)	Streptococci, fecal, (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
10N/19E-11A02	07-18-89	15.0	273	7.1	5.6	--	--	3.00	<1	<1	<1
10N/19E-11B05	08-30-89	15.5	310	7.1	--	--	--	5.40	<1	K4	<1
10N/19E-11P01	09-13-89	15.0	308	7.8	4.6	--	--	3.60	<1	<1	<1
10N/19E-11R01	07-19-89	15.0	292	7.3	5.4	--	--	3.40	<1	<1	<1
10N/19E-12M01	09-14-89	15.0	280	7.6	5.3	--	--	2.80	<1	<1	<1
10N/19E-12Q02	07-26-89	15.0	319	7.0	5.4	--	--	4.00	<1	<1	<1
10N/19E-15C01	07-19-89	14.5	338	7.8	5.1	--	--	4.50	<1	<1	<1
10N/19E-16D01	07-19-89	17.0	299	7.6	3.8	--	--	2.70	<1	<1	<1
10N/19E-18A01	07-19-89	15.5	280	7.0	5.5	--	--	2.90	<1	<1	<1
10N/19E-18B01	09-13-89	15.0	260	7.1	4.2	--	--	2.10	<1	<1	<1
10N/19E-18Q01	07-19-89	14.5	290	7.3	3.1	--	--	1.80	<1	<1	<1
10N/19E-21B01	08-08-89	14.5	325	7.6	5.4	--	--	4.00	<1	<1	<1
10N/19E-21D01	07-27-89	14.0	260	7.2	4.7	<0.010	<0.20	3.00	<1	<1	<1
10N/19E-21D02	08-14-89	15.5	272	7.1	5.2	--	--	3.30	<1	<1	<1
10N/19E-21H03	08-08-89	14.5	323	7.5	4.9	--	--	3.90	<1	<1	<1
10N/19E-21K01	09-14-89	14.0	310	7.3	5.0	--	--	4.10	<1	<1	<1
10N/19E-21M01	08-07-89	15.0	315	7.4	3.5	--	--	3.00	<1	<1	<1
10N/19E-25A01	07-19-89	17.0	368	7.4	4.7	--	--	5.30	<1	<1	<1
10N/19E-25B02	07-19-89	14.5	380	7.4	3.3	--	--	5.50	<1	<1	<1
10N/19E-25H01	08-07-89	14.0	375	7.4	2.6	--	--	5.10	<1	<1	<1
10N/19E-25H02	08-07-89	14.0	370	7.4	2.6	--	--	5.00	<1	<1	<1
10N/19E-25H03	08-08-89	14.5	409	7.3	2.2	<0.010	0.20	5.10	<1	<1	<1
10N/19E-26M01	07-20-89	17.0	306	8.1	2.3	<0.010	0.60	<0.10	<1	<1	<1
10N/19E-30R01	07-19-89	23.0	370	7.8	7.0	--	--	0.10	<1	<1	<1
10N/19E-34K01	07-19-89	17.5	430	7.5	--	0.010	2.90	0.10	<1	<1	<1
10N/20E-01P01	07-24-89	14.5	280	7.0	2.4	0.010	0.40	3.30	<1	8	<1
10N/20E-01P03	09-12-89	15.0	214	7.0	2.1	--	--	1.30	<1	<1	<1
10N/20E-01Q02	09-12-89	16.5	212	8.0	3.4	--	--	0.10	<1	<1	<1
10N/20E-01Q03	09-12-89	15.5	112	6.9	1.9	--	--	1.00	<1	<1	<1
10N/20E-03P01	07-25-89	14.0	221	7.0	4.1	--	--	2.60	<1	<1	<1
10N/20E-04J01	07-25-89	14.0	182	7.3	5.2	--	--	1.90	<1	<1	<1
10N/20E-04K01	07-24-89	15.0	203	6.9	5.3	--	--	1.40	--	--	--
10N/20E-04L01	07-25-89	23.5	219	8.0	0.1	0.030	0.20	<0.10	<1	<1	<1
10N/20E-04Q01	07-24-89	14.5	189	6.9	4.9	--	--	1.10	<1	<1	<1
10N/20E-05A02	09-13-89	16.0	180	7.0	5.7	--	--	2.50	<1	<1	<1
10N/20E-05H01	07-21-89	15.0	182	7.0	5.8	--	--	1.40	<1	<1	<1
10N/20E-05M02	09-14-89	15.5	230	6.9	4.7	--	--	3.60	<1	<1	<1
10N/20E-06C01	08-22-89	15.0	252	7.5	9.5	--	--	2.20	<1	<1	<1
10N/20E-06N02	08-03-89	21.5	272	6.9	6.3	--	--	4.00	<1	<1	<1
10N/20E-07P01	07-20-89	14.5	279	7.0	6.0	<0.010	1.2	4.00	<1	<1	<1
10N/20E-08C02	07-21-89	18.5	236	7.1	5.9	--	--	3.10	<1	<1	<1
10N/20E-09D01	08-04-89	15.5	104	8.3	5.0	--	--	0.20	<1	<1	<1
10N/20E-09D02	08-04-89	14.5	189	7.3	--	--	--	0.70	<1	K2	<1
10N/20E-09P01	07-20-89	14.0	249	6.9	5.1	--	--	3.90	<1	<1	<1
10N/20E-10J01	07-20-89	19.5	292	7.1	5.9	--	--	3.30	<1	<1	<1
10N/20E-11P01	07-20-89	13.5	332	6.8	1.2	<0.010	0.50	4.00	<1	<1	<1
10N/20E-12A01	08-04-89	15.5	278	7.0	0.8	<0.010	<0.20	0.70	<1	<1	<1
10N/20E-12C01	07-21-89	13.0	266	7.0	2.2	--	--	1.90	<1	<1	<1
10N/20E-13A01	07-21-89	13.5	340	6.9	1.3	<0.010	0.70	3.10	<1	<1	<1
10N/20E-13E02	07-25-89	15.0	344	7.2	1.0	0.010	0.40	2.20	<1	<1	<1

Appendix 1.--*Ground-water-quality data, July-September, 1989--Continued*

Local well number	Date	Temperature water (Deg C)	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, ammonia+ organic total (mg/L as N)	Nitrogen, NO_2 $+NO_3$ total (mg/L as N)	Coliform, fecal, (cols./ 100 ml)	Streptococci, fecal, (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
10N/20E-13E03	08-09-89	14.0	389	6.9	1.3	<0.010	<0.20	3.20	<1	<1	<1
10N/20E-14E01	07-25-89	14.5	295	7.3	2.6	0.020	0.50	3.00	<1	<1	<1
10N/20E-14L01	09-13-89	15.0	280	7.1	4.0	--	--	<0.10	<1	<1	<1
10N/20E-14L03	08-04-89	15.0	292	7.0	2.6	--	--	2.60	<1	<1	<1
10N/20E-15B02	07-20-89	15.5	230	7.0	5.8	--	--	2.90	<1	<1	<1
10N/20E-16A01	08-08-89	18.5	198	6.8	4.0	--	--	1.60	<1	<1	<1
10N/20E-16G01	09-26-89	15.0	255	7.1	4.2	--	--	3.30	<1	<1	<1
10N/20E-16P01	07-21-89	14.0	310	7.3	4.0	--	--	4.50	<1	<1	<1
10N/20E-17F01	07-26-89	15.5	300	7.2	6.8	--	--	4.30	<1	K2	K5
10N/20E-17H01	08-03-89	14.0	315	7.0	4.7	--	--	4.30	<1	K2	<1
10N/20E-17J01	08-04-89	14.0	329	7.1	4.6	--	--	4.30	<1	<1	<1
10N/20E-17P01	08-08-89	14.5	320	7.0	5.1	<0.010	<0.20	4.50	<1	<1	<1
10N/20E-18D01	07-20-89	14.0	300	7.4	5.1	--	--	3.20	<1	<1	<1
10N/20E-18L01	07-25-89	15.5	340	7.6	4.2	--	--	4.50	<1	<1	<1
10N/20E-18N01	07-25-89	14.0	325	7.2	5.4	--	--	4.10	<1	<1	<1
10N/20E-19J01	07-26-89	15.5	377	7.5	4.3	--	--	4.30	<1	<1	<1
10N/20E-20K01	07-24-89	14.5	369	7.3	3.8	0.010	0.40	3.80	<1	<1	<1
10N/20E-20M01	07-24-89	17.0	365	7.4	3.4	--	--	4.00	<1	<1	<1
10N/20E-20P01	07-24-89	15.0	320	7.9	3.2	--	--	4.60	<1	<1	<1
10N/20E-21B01	09-14-89	15.0	308	7.1	3.2	--	--	3.50	<1	<1	<1
10N/20E-21G01	07-27-89	14.5	330	7.2	3.4	--	--	4.70	<1	<1	<1
10N/20E-21G02	07-27-89	14.0	355	7.1	3.2	--	--	5.80	<1	<1	<1
10N/20E-21J01	07-25-89	16.0	390	7.3	3.3	--	--	5.30	<1	<1	<1
10N/20E-25H01	07-27-89	15.0	395	7.2	1.1	<0.010	0.20	1.70	<1	>33	<1
10N/20E-27A01	09-13-89	15.0	242	7.5	2.1	--	--	0.30	<1	<1	<1
10N/20E-28H02	08-08-89	14.5	362	7.1	3.1	--	--	5.50	<1	<1	<1
10N/20E-29E01	08-22-89	18.0	371	7.2	2.3	--	--	5.40	<1	K9	<1
10N/20E-29H01	08-22-89	16.0	252	7.3	2.3	--	--	2.70	<1	<1	<1
10N/21E-05C01	07-26-89	15.5	397	7.9	5.3	--	--	1.10	<1	<1	<1
10N/21E-06A01	07-26-89	15.5	481	7.6	5.4	--	--	2.30	<1	<1	<1
10N/21E-07L01	07-26-89	15.0	247	7.0	2.9	--	--	1.40	<1	<1	<1
10N/21E-18D01	07-26-89	14.0	382	6.9	2.0	<0.010	0.30	4.60	<1	<1	<1
10N/21E-28F01	07-26-89	14.5	365	7.1	3.2	--	--	1.90	<1	<1	<1
10N/21E-28P01	07-27-89	15.0	372	7.2	2.6	<0.010	0.30	2.20	<1	<1	<1
10N/21E-29A01	08-23-89	15.5	320	7.6	0.1	0.030	<0.20	<0.10	<1	<1	<1
10N/21E-29G01	07-27-89	16.0	319	7.1	0.1	<0.010	0.70	0.30	<1	<1	<1
10N/21E-30C01	08-23-89	16.0	259	7.9	0.1	0.030	<0.20	<0.10	<1	<1	<1
10N/21E-30H01	07-28-89	15.0	268	7.8	0.1	0.030	<0.20	<0.10	<1	<1	<1
10N/21E-30J01	08-22-89	15.0	277	7.8	0.1	0.040	<0.20	<0.10	<1	K1	<1
10N/21E-32K02	08-23-89	17.0	277	8.2	0.0	0.040	<0.20	<0.10	<1	<1	<1
10N/21E-33B02	07-27-89	15.5	402	7.1	0.2	<0.010	0.90	4.60	<1	1	<1
10N/21E-33C01	09-14-89	13.5	372	7.1	4.0	--	--	<.10	<1	<1	<1
10N/21E-33C03	08-23-89	16.0	288	8.0	0.2	0.050	<0.20	<.10	<1	<1	<1
10N/21E-33K01	07-28-89	15.5	267	7.1	0.3	0.010	<0.20	0.40	<1	<1	<1
10N/21E-34L01	08-23-89	15.0	310	7.1	0.1	<0.010	<0.20	1.10	<1	<1	<1
10N/21E-35J01	08-24-89	15.5	388	7.1	3.0	<0.010	1.0	3.40	<1	<1	<1
11N/16E-09P03	08-14-89	15.5	220	7.4	4.8	--	--	1.10	<1	<1	<1
11N/16E-09P01	09-14-89	16.0	210	7.4	4.8	--	--	1.00	<1	<1	<1
11N/16E-09P02	09-14-89	18.5	225	7.0	--	--	--	1.00	<1	K52	<1
11N/16E-11P02	08-15-89	14.0	171	7.2	8.1	--	--	0.90	<1	<1	<1

Appendix 1.--*Ground-water-quality data, July-September, 1989--Continued*

Local well number	Date	Temperature water (Deg C)	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, ammonia+ organic total (mg/L as N)	Nitrogen, NO_2 $+NO_3$ total (mg/L as N)	Coliform, fecal, (cols./ 100 ml)	Streptococci, fecal, (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
11N/16E-16P02	08-16-89	14.5	204	7.6	5.8	--	--	0.90	<1	K1	<1
11N/16E-21J01	08-16-89	18.5	178	7.0	3.8	<0.010	0.30	0.50	<1	<1	<1
11N/16E-22M02	08-18-89	14.5	195	7.3	7.6	--	--	0.40	<1	<1	<1
11N/16E-23B02	08-15-89	13.0	368	7.1	3.1	--	--	0.60	<1	<1	<1
11N/16E-25G01	09-12-89	18.0	207	7.5	3.7	--	--	<0.10	<1	<1	--
11N/16E-25H01	08-15-89	17.5	167	7.6	2.3	--	--	0.50	<1	<1	<1
11N/16E-25H02	09-12-89	16.5	219	7.3	5.3	--	--	0.30	<1	K2	<1
11N/16E-25J01	08-21-89	20.0	196	7.3	2.8	--	--	0.60	<1	<1	<1
11N/16E-25J02	08-21-89	17.0	189	7.3	5.6	<0.010	<0.20	0.70	<1	<1	<1
11N/16E-25J03	09-12-89	16.0	180	7.4	3.5	--	--	0.70	<1	<1	<1
11N/16E-25N01	09-12-89	14.5	615	7.5	5.3	--	--	3.50	<1	<1	<1
11N/16E-27C02	08-15-89	14.5	314	7.1	6.9	--	--	1.10	<1	<1	<1
11N/16E-28F02	08-16-89	13.0	174	7.4	7.2	--	--	0.40	<1	K3	<1
11N/16E-28L01	08-16-89	14.5	181	7.6	4.8	--	--	0.30	<1	<1	<1
11N/16E-34K03	08-22-89	22.5	409	6.5	0.0	0.030	<0.20	<0.10	<1	<1	<1
11N/16E-35J01	09-12-89	15.5	405	7.5	4.8	--	--	3.20	<1	<1	--
11N/16E-35Q01	08-15-89	14.0	326	7.0	6.7	--	--	0.50	<1	<1	<1
11N/17E-01A01	08-31-89	19.5	270	8.0	--	--	--	<0.10	<1	<1	<1
11N/17E-02P01	08-31-89	25.5	280	8.0	0.6	0.020	<0.20	<0.10	<1	<1	<1
11N/17E-03L02	09-14-89	25.5	270	7.9	0.0	0.020	0.20	<0.10	<1	<1	<1
11N/17E-11Q01	08-09-89	13.0	1,100	7.6	5.4	--	--	1.90	<1	<1	<1
11N/17E-11Q02	08-22-89	13.0	1,040	7.6	4.1	--	--	1.90	<1	<1	<1
11N/17E-12J02	08-08-89	16.5	270	7.6	1.4	--	--	0.50	<1	10	<1
11N/17E-12J03	08-23-89	16.5	255	7.6	2.3	--	--	0.60	<1	<1	<1
11N/17E-12R01	08-08-89	16.5	272	7.8	2.5	0.010	<0.20	<0.10	<1	<1	<1
11N/17E-16F01	09-14-89	18.0	338	7.6	1.9	0.010	<0.20	0.70	<1	<1	<1
11N/17E-16H01	08-09-89	20.5	259	7.9	0.3	0.030	<0.20	<0.10	<1	<1	<1
11N/17E-16R01	08-22-89	16.5	280	7.3	2.2	--	--	3.00	<1	K190	<1
11N/17E-16R02	08-22-89	14.0	358	7.8	7.2	--	--	--	<1	<1	<1
11N/17E-16R03	09-01-89	13.5	700	7.6	6.4	<0.010	<0.20	2.60	<1	<1	<1
11N/17E-17P01	09-14-89	19.0	443	7.5	2.3	0.030	<0.20	<0.10	<1	<1	<1
11N/17E-19C01	09-15-89	21.5	590	6.8	0.0	0.040	<0.20	<0.10	<1	<1	<1
11N/17E-19E01	08-31-89	19.5	205	7.1	0.4	0.020	<0.20	<0.10	<1	<1	<1
11N/17E-20B01	08-08-89	17.5	244	7.4	4.7	--	--	0.20	<1	<1	<1
11N/17E-20F01	09-15-89	18.5	448	7.4	1.0	0.030	<0.20	<0.10	<1	<1	<1
11N/17E-21J01	09-12-89	14.5	250	7.1	7.9	--	--	0.30	<1	10	<1
11N/17E-21P01	08-09-89	15.5	218	7.1	8.3	<0.010	<0.20	0.20	<1	<1	<1
11N/17E-22G01	08-23-89	14.0	756	7.3	6.1	--	--	3.30	<1	K73	<1
11N/17E-23D02	08-24-89	14.0	373	7.2	5.8	--	--	0.90	<1	<1	<1
11N/17E-23M01	08-09-89	15.0	330	7.4	6.6	--	--	0.50	<1	<1	<1
11N/17E-24N01	08-10-89	14.0	640	7.6	0.4	0.010	0.50	0.60	<1	<1	<1
11N/17E-24R01	08-10-89	15.5	575	7.4	0.3	<0.010	1.3	2.90	<1	<1	<1
11N/17E-24R02	09-15-89	14.5	740	7.5	0.1	0.010	<0.20	3.50	<1	<1	<1
11N/17E-27Q01	08-10-89	13.0	405	7.2	5.4	--	--	1.20	<1	<1	<1
11N/17E-28D02	08-10-89	14.0	350	7.0	4.6	--	--	1.10	<1	<1	<1
11N/17E-30Q01	09-15-89	19.5	430	7.4	0.8	0.040	<0.20	<0.10	<1	K2	<1
11N/17E-31L02	08-28-89	13.5	760	8.0	0.5	<0.010	0.30	0.60	<1	<1	<1
11N/17E-32L02	09-01-89	13.5	230	7.6	5.4	--	--	0.70	<1	<1	<1
11N/17E-32N01	08-24-89	14.5	175	7.6	0.1	<0.010	0.40	<0.10	<1	<1	<1
	08-28-89	14.0	182	8.2	0.1	--	--	--	<1	<1	<1

Appendix 1.--*Ground-water-quality data, July-September, 1989--Continued*

Local well number	Date	Temperature water (Deg C)	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, ammonia+ organic total (mg/L as N)	Nitrogen, NO_2 $+NO_3$ total (mg/L as N)	Coliform, fecal, (cols./ 100 ml)	Streptococci, fecal, (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
11N/17E-33K01	08-11-89	14.5	292	7.3	2.4	--	--	0.20	<1	<1	<1
11N/17E-34M01	08-11-89	15.0	164	7.7	0.8	<0.010	<0.20	0.10	<1	K1	<1
11N/18E-01B02	06-20-89	14.0	220	7.3	7.4	--	--	0.90	<1	<1	<1
11N/18E-01M02	06-21-89	13.0	300	7.2	7.6	--	--	3.10	<1	<1	<1
11N/18E-02P01	06-29-89	16.0	360	7.8	15.3	--	--	1.30	<1	<1	<1
11N/18E-03D01	07-18-89	16.5	200	7.7	0.4	0.020	<0.20	<0.10	<1	<1	<1
11N/18E-03N01	07-18-89	15.0	342	7.8	6.7	--	--	2.70	<1	<1	<1
11N/18E-04H01	06-30-89	14.5	756	7.6	12.3	--	--	4.40	<1	<1	<1
11N/18E-05N01	06-30-89	15.0	452	7.4	9.1	--	--	1.20	<1	K11	<1
11N/18E-06J01	06-27-89	14.0	330	7.4	4.2	--	--	0.70	<1	<1	<1
11N/18E-06K01	06-27-89	15.0	305	7.9	6.5	--	--	0.70	<1	K2	<1
11N/18E-06N01	06-27-89	16.0	290	8.0	0.5	--	--	<0.10	<1	<1	<1
11N/18E-07N01	06-27-89	13.0	590	7.6	2.4	0.010	<0.20	0.90	<1	<1	<1
11N/18E-07P01	06-27-89	13.5	730	7.4	2.3	--	--	0.90	<1	<1	<1
11N/18E-10C01	08-17-89	15.5	510	7.6	8.5	--	--	23.00	<1	<1	<1
11N/18E-10D01	09-27-89	15.0	306	7.6	8.2	--	--	2.40	<1	<1	<1
11N/18E-10J01	06-27-89	15.0	560	7.7	6.0	--	--	4.50	<1	<1	<1
11N/18E-11C01	06-20-89	16.5	445	7.8	7.7	--	--	3.10	<1	<1	<1
11N/18E-11D01	06-21-89	16.0	510	7.7	5.0	--	--	1.90	<1	<1	<1
11N/18E-11R01	06-21-89	12.5	420	7.3	6.6	--	--	3.60	<1	K1	<1
11N/18E-12H01	06-20-89	14.5	230	7.1	5.6	--	--	1.80	<1	<1	<1
11N/18E-12J01	06-20-89	15.5	260	7.2	5.2	--	--	2.50	<1	<1	<1
11N/18E-12P01	06-20-89	14.0	300	7.4	4.8	--	--	1.90	<1	<1	<1
11N/18E-13A01	06-21-89	13.5	280	7.2	5.7	--	--	2.70	<1	<1	<1
11N/18E-13B02	06-22-89	14.0	370	8.0	--	--	--	3.10	<1	<1	<1
11N/18E-13R01	06-21-89	14.0	240	7.2	6.6	--	--	1.80	<1	<1	<1
11N/18E-13R02	06-21-89	14.0	265	7.3	6.0	<0.010	0.40	2.10	<1	<1	<1
11N/18E-14E01	08-07-89	15.5	695	7.7	8.1	--	--	2.60	<1	<1	<1
11N/18E-17B01	06-23-89	19.5	245	7.8	0.4	--	--	<0.10	<1	<1	<1
11N/18E-17C01	06-23-89	14.0	530	7.8	0.9	--	--	3.00	<1	<1	<1
11N/18E-17D03	08-28-89	14.0	510	7.8	1.9	<0.010	<0.20	0.80	<1	<1	<1
11N/18E-18D01	06-26-89	14.5	560	7.6	4.5	--	--	1.30	<1	<1	<1
11N/18E-18M01	06-26-89	13.5	570	7.5	0.0	--	--	<0.10	<1	<1	<1
11N/18E-18Q01	08-03-89	14.0	756	7.6	1.5	<0.010	<0.20	1.10	<1	<1	<1
11N/18E-20H01	06-28-89	14.0	378	7.7	2.4	--	--	1.10	<1	<1	<1
11N/18E-21E01	06-22-89	14.0	480	7.7	4.0	--	--	2.40	<1	K6	<1
11N/18E-21R01	06-22-89	15.0	490	7.7	6.4	--	--	1.70	<1	>33	<1
11N/18E-22D01	08-07-89	14.0	725	7.5	3.8	--	--	7.80	<1	<1	<1
11N/18E-22R01	06-22-89	15.0	340	7.3	5.4	--	--	4.50	<1	<1	<1
11N/18E-22R02	06-28-89	13.5	290	7.2	5.9	--	--	5.20	<1	<1	<1
11N/18E-24C01	06-22-89	14.5	300	7.3	6.9	--	--	2.70	<1	<1	<1
11N/18E-25M01	06-22-89	14.0	340	7.3	11.4	--	--	4.00	<1	<1	<1
11N/18E-25M02	06-23-89	14.0	340	7.3	6.7	--	--	3.70	<1	<1	<1
11N/18E-26M03	06-29-89	--	402	7.6	0.3	0.020	<0.20	<0.10	<1	<1	<1
11N/18E-26N04	08-03-89	14.5	381	7.3	5.9	--	--	2.90	<1	<1	<1
11N/18E-26P01	06-29-89	13.5	363	7.3	9.4	--	--	5.70	<1	<1	<1
11N/18E-27N01	06-26-89	14.5	490	7.4	4.8	--	--	9.30	<1	<1	<1
11N/18E-27R01	06-26-89	13.5	440	7.1	6.2	--	--	11.00	<1	<1	<1
11N/18E-27R02	08-29-89	14.5	320	7.3	5.7	--	--	4.90	<1	<1	<1
11N/18E-28H01	06-23-89	14.0	330	7.8	2.8	<0.010	<0.20	1.20	<1	<1	<1

Appendix 1.--*Ground-water-quality data, July-September, 1989--Continued*

Local well number	Date	Temperature water (Deg C)	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, ammonia+organic total (mg/L as N)	Nitrogen, NO_2 $+NO_3$ total (mg/L as N)	Coliform, fecal, (cols./100 ml)	Streptococci, fecal, (cols./100 ml)	*Escherichia coli* (cols./100 ml)
11N/18E-29N01	06-26-89	16.0	540	7.4	1.5	--	--	4.70	<2	<2	<2
11N/18E-29R01	06-23-89	15.5	510	7.6	1.5	--	--	0.80	<1	<1	<1
11N/18E-31A01	08-03-89	15.5	696	7.3	0.1	0.010	<0.20	3.30	<1	<1	<1
11N/18E-31J01	06-28-89	13.0	620	7.3	0.0	--	--	0.40	<1	<1	<1
11N/18E-31J02	06-28-89	14.0	690	7.3	0.1	--	--	1.00	<1	<1	<1
11N/18E-31R03	06-28-89	14.0	595	7.7	0.7	--	--	<0.10	<1	<1	<1
11N/18E-33D02	06-23-89	14.0	520	7.7	1.3	--	--	0.60	<1	<1	<1
11N/18E-34C01	08-03-89	16.0	358	7.4	--	--	--	5.30	<1	<1	<1
11N/18E-36R01	06-29-89	15.0	259	7.0	6.4	--	--	1.90	<1	<1	<1
11N/19E-02M01	07-05-89	12.5	162	6.9	2.3	--	--	0.40	<1	<1	<1
11N/19E-02M02	07-05-89	13.0	138	6.7	1.9	--	--	0.20	<1	<1	<1
11N/19E-03M01	07-05-89	14.5	157	6.9	5.2	--	--	0.80	<1	<1	<1
11N/19E-03N01	07-06-89	14.5	177	6.6	6.0	--	--	1.40	<1	<1	<1
11N/19E-03R01	07-06-89	14.0	180	6.9	7.5	--	--	1.30	<1	<1	<1
11N/19E-03R02	08-22-89	14.0	184	7.4	3.5	--	--	0.70	<1	<1	<1
11N/19E-04D01	09-27-89	15.0	231	6.8	6.2	--	--	2.00	<1	<1	<1
11N/19E-04E01	07-06-89	14.5	200	6.7	6.6	--	--	1.60	<1	<1	<1
11N/19E-04H02	08-22-89	14.5	182	6.9	6.8	--	--	1.30	<1	<1	<1
11N/19E-04P01	07-07-89	13.5	162	6.8	6.6	--	--	0.80	<1	<1	<1
11N/19E-04P02D1	07-14-89	13.5	165	7.0	8.4	--	--	0.50	<1	K7	<1
11N/19E-04P03	07-14-89	14.5	165	6.9	7.4	--	--	0.60	<1	<1	<1
11N/19E-06M01	08-07-89	15.5	328	7.4	5.8	<0.010	<0.20	2.40	<1	<1	<1
11N/19E-06N01	07-13-89	15.5	225	7.0	4.5	--	--	0.90	<1	<1	<1
11N/19E-06R02	07-14-89	14.0	242	7.1	7.3	--	--	3.80	<1	<1	<1
11N/19E-07D01	07-18-89	14.5	203	6.9	5.7	--	--	1.30	K1	K2	<1
11N/19E-07N02	07-12-89	13.5	247	7.1	5.1	--	--	2.10	<1	<1	<1
11N/19E-08J01	07-07-89	14.5	235	7.2	6.1	0.010	0.40	1.60	<1	<1	<1
11N/19E-08J02	07-13-89	14.5	255	7.5	5.9	--	--	1.70	<1	<1	<1
11N/19E-08N02	09-27-89	15.5	743	7.2	6.6	--	--	2.10	<1	<1	<1
11N/19E-09C01	08-24-89	14.0	157	7.1	8.8	--	--	0.60	<1	<1	<1
11N/19E-09G02	07-17-89	14.0	189	6.9	7.2	--	--	1.00	<1	<1	<1
11N/19E-09G01	08-14-89	14.0	185	6.9	5.2	--	--	0.80	<1	<1	<1
11N/19E-09H02	08-07-89	15.0	161	7.0	6.6	--	--	0.50	<1	<1	<1
11N/19E-10B01	07-18-89	19.0	149	8.2	--	--	--	<0.10	<1	<1	<1
11N/19E-10D01	07-07-89	15.0	206	7.7	5.2	--	--	1.20	<1	K17	<1
11N/19E-10E03	07-07-89	14.5	154	7.1	6.9	--	--	0.60	<1	<1	<1
11N/19E-10G01	07-10-89	14.5	164	6.9	7.8	--	--	1.10	<1	<1	<1
11N/19E-10G02	07-10-89	14.0	165	6.9	7.6	--	--	1.20	<1	<1	<1
11N/19E-10M01	07-11-89	15.0	119	6.7	6.7	--	--	1.00	<1	<1	<1
11N/19E-10P01	07-17-89	15.5	165	7.1	7.8	--	--	1.20	K1	<1	<1
11N/19E-11M01	07-11-89	13.5	175	6.8	2.9	--	--	0.80	<1	K1	<1
11N/19E-12R01	07-11-89	14.0	155	7.0	1.6	<0.010	0.20	0.30	<1	<1	<1
11N/19E-13A01	08-11-89	13.5	156	6.8	3.6	--	--	0.60	<1	<1	<1
11N/19E-13A02	08-11-89	13.5	163	6.8	3.0	--	--	0.90	<1	<1	<1
11N/19E-13H01	07-11-89	13.5	157	6.9	2.9	--	--	0.60	<1	<1	<1
11N/19E-13K01	07-11-89	14.0	165	6.8	4.4	--	--	1.20	<1	<1	<1
11N/19E-14E01	08-25-89	16.0	216	7.0	7.6	--	--	1.90	<1	<1	<1
11N/19E-14D02	08-25-89	23.0	131	8.6	2.6	--	--	<0.10	<1	<1	<1
11N/19E-14N01	07-12-89	17.5	169	6.7	6.8	--	--	1.60	<1	<1	<1
11N/19E-14N02	07-12-89	16.5	194	7.1	6.0	--	--	1.30	<1	<1	<1

Appendix 1.--*Ground-water-quality data, July-September, 1989--Continued*

Local well number	Date	Temperature water (Deg C)	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, ammonia+ organic total (mg/L as N)	Nitrogen, NO_2 $+NO_3$ total (mg/L as N)	Coliform, fecal, (cols./ 100 ml)	Streptococci, fecal, (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
11N/19E-14N03	08-15-89	17.0	195	6.8	6.3	--	--	1.30	<1	<1	<1
11N/19E-15E02	07-12-89	18.0	225	6.8	6.6	--	--	1.80	<1	<1	<1
11N/19E-15F01	07-12-89	16.5	218	6.8	6.0	0.020	0.20	1.80	<1	<1	<1
11N/19E-15F02	07-12-89	17.0	225	7.6	4.5	--	--	1.40	<1	<1	<1
11N/19E-15F03	08-25-89	14.5	235	6.9	7.7	--	--	1.10	<1	<1	<1
11N/19E-16A01	09-27-89	15.5	202	6.6	6.0	--	--	0.90	<1	<1	<1
11N/19E-16J02	09-27-89	15.5	235	6.9	5.8	--	--	1.40	<1	<1	<1
11N/19E-16D01	07-13-89	17.0	255	7.5	4.9	--	--	1.90	<1	<1	<1
11N/19E-17J01	07-14-89	15.0	301	7.1	6.3	--	--	2.90	<1	<1	<1
11N/19E-17N01	07-13-89	15.0	263	6.8	6.9	--	--	4.00	<1	<1	<1
11N/19E-17P01	08-24-89	15.5	227	7.1	6.5	--	--	2.10	<1	<1	<1
11N/19E-18D01	07-13-89	18.0	316	7.1	4.5	--	--	2.10	<1	<1	<1
11N/19E-18N01	08-14-89	14.5	311	7.0	4.8	<0.010	0.30	2.60	<1	<1	<1
11N/19E-18N02	08-14-89	15.0	300	7.0	5.4	--	--	2.30	<1	<1	<1
11N/19E-19E02	09-15-89	16.0	283	7.4	--	--	--	2.50	K3	K1	K1
11N/19E-20H01	07-14-89	13.5	277	7.3	6.6	--	--	2.20	<1	<1	<1
11N/19E-20H02	07-14-89	14.0	244	7.3	6.6	--	--	1.90	<1	<1	<1
11N/19E-21Q02	07-11-89	14.5	289	7.3	6.2	--	--	2.80	<1	<1	<1
11N/19E-21R01	07-11-89	15.5	267	7.0	6.6	--	--	2.40	<1	<1	<1
11N/19E-22A01	07-13-89	15.5	155	6.9	6.2	--	--	1.70	<1	<1	<1
11N/19E-22A02	08-24-89	14.0	208	6.9	6.7	--	--	1.40	<1	<1	<1
11N/19E-22A05	07-11-89	15.0	195	6.7	5.6	--	--	1.40	<1	<1	<1
11N/19E-22M01	07-19-89	15.0	199	7.1	6.4	--	--	2.00	<1	<1	<1
11N/19E-23A01	07-12-89	16.0	225	7.6	0.7	0.020	<0.20	0.60	<1	<1	<1
11N/19E-23E01	08-24-89	17.0	204	6.8	6.7	--	--	1.30	<1	<1	<1
11N/19E-23Q03	07-17-89	16.0	187	6.8	3.4	--	--	3.50	<1	<1	<1
11N/19E-24H01	07-12-89	16.0	155	6.1	5.8	--	--	0.60	<1	<1	<1
11N/19E-24R01	08-15-89	14.0	164	6.8	4.4	--	--	0.50	<1	<1	<1
11N/19E-25B01	07-12-89	15.5	179	6.8	6.9	--	--	1.20	<1	<1	<1
11N/19E-25B02	08-15-89	17.0	205	7.0	--	--	--	1.80	12	K33	11
11N/19E-25C01	08-24-89	15.0	201	6.8	6.3	--	--	1.90	<1	<1	<1
11N/19E-26A02	09-15-89	15.5	180	6.9	3.0	--	--	2.40	<1	<1	<1
11N/19E-26C01	08-24-89	15.0	260	6.9	7.7	--	--	3.40	<1	<1	<1
11N/19E-26C02	07-12-89	16.0	196	6.9	7.4	--	--	2.40	<1	<1	<1
11N/19E-27D03	07-11-89	14.5	272	7.1	6.5	--	--	2.50	<1	<1	<1
11N/19E-27R01	07-13-89	15.5	248	7.1	4.9	--	--	2.80	<1	<1	<1
11N/19E-28A01	09-27-89	16.0	260	6.6	7.3	<0.010	<0.20	4.00	<1	<1	<1
11N/19E-28C01	07-11-89	15.5	289	7.2	6.6	--	--	3.10	<1	<1	<1
11N/19E-28E01	07-11-89	14.0	258	6.8	7.3	--	--	2.40	<1	<1	<1
11N/19E-28P01	07-14-89	14.0	290	7.1	7.6	--	--	2.80	<1	<1	<1
11N/19E-29N01	07-20-89	13.5	308	7.0	6.2	--	--	7.00	<1	<1	<1
11N/19E-29N02	07-20-89	14.5	278	7.4	7.8	--	--	2.80	<1	<1	<1
11N/19E-30D02	07-14-89	13.5	261	7.0	6.4	--	--	1.60	<1	<1	<1
11N/19E-30D03	08-25-89	14.0	259	6.8	5.7	--	--	2.30	<1	<1	<1
11N/19E-31F01D1	07-14-89	--	261	7.6	6.4	--	--	1.90	<1	<1	<1
11N/19E-33E01	07-21-89	14.5	228	7.1	6.0	--	--	2.60	<1	<1	<1
11N/19E-34C01	07-13-89	16.5	271	7.3	5.2	--	--	2.80	<1	<1	<1
11N/19E-34E01	07-13-89	17.5	260	7.1	6.8	--	--	3.20	<1	<1	<1
11N/19E-34M02	07-26-89	16.0	299	7.3	6.1	<0.010	<0.20	3.40	<1	<1	<1
11N/19E-35A02	07-27-89	15.0	276	7.1	6.1	--	--	4.60	<1	<1	<1

Appendix 1.--*Ground-water-quality data, July-September, 1989--Continued*

Local well number	Date	Temperature water (Deg C)	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, ammonia+ organic total (mg/L as N)	Nitrogen, NO_2 $+NO_3$ total (mg/L as N)	Coliform, fecal, (cols./ 100 ml)	Streptococci, fecal, (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
11N/19E-35G01	07-13-89	14.0	278	7.4	5.4	--	--	2.90	<1	<1	<1
11N/19E-35G02	07-13-89	14.0	235	7.1	6.0	--	--	2.90	<1	K6	<1
11N/19E-36B01	07-13-89	15.0	189	6.7	5.2	<0.010	0.30	2.40	<1	<1	<1
11N/19E-36P01	07-21-89	15.5	262	6.8	6.0	--	--	4.90	<1	<1	<1
11N/20E-19M01	07-28-89	15.5	172	6.9	4.2	--	--	0.40	<1	<1	<1
11N/20E-20M01	09-14-89	16.0	160	6.6	1.3	--	--	0.30	<1	<1	<1
11N/20E-28M01	08-08-89	--	196	6.9	3.3	--	--	1.70	<1	<1	<1
11N/20E-28N01	07-27-89	14.0	181	6.7	4.3	--	--	1.20	<1	<1	<1
11N/20E-29Q01	07-27-89	14.0	188	6.8	6.2	--	--	2.40	<1	<1	<1
11N/20E-30L01	07-26-89	16.0	180	7.0	6.4	--	--	1.00	<1	K1	<1
11N/20E-30M01	08-08-89	15.0	180	6.9	5.8	--	--	1.10	<1	<1	<1
11N/20E-30R01	08-07-89	15.0	168	7.0	5.2	--	--	0.40	<1	<1	<1
11N/20E-31D02	08-14-89	15.5	210	6.9	5.6	--	--	1.90	<1	<1	<1
11N/20E-31E02	08-14-89	16.0	180	6.7	4.6	--	--	1.10	<1	<1	<1
11N/20E-31E03	08-08-89	15.5	200	6.9	5.8	--	--	1.60	<1	K2	<1
11N/20E-32N01	08-14-89	18.0	180	6.7	5.2	--	--	1.10	<1	<1	<1
11N/20E-33N03	08-07-89	15.0	--	6.8	5.3	<0.010	0.30	3.00	<1	<1	<1
11N/20E-33N04	08-07-89	14.0	234	6.9	5.7	--	--	4.70	<1	<1	<1
11N/20E-34R01	09-26-89	14.0	110	7.4	2.9	--	--	0.20	<1	K1	<1
12N/18E-23N02	08-17-89	26.0	310	8.6	0.2	0.020	<0.20	<0.10	<1	<1	<1
12N/18E-26C01	08-29-89	24.5	300	7.9	0.0	0.020	<0.20	<0.10	<1	<1	<1
12N/18E-27N02D1	08-30-89	23.5	265	7.9	0.0	0.030	<0.20	<0.10	<1	<1	<1
12N/18E-35H01	08-30-89	16.0	565	7.5	3.7	--	--	3.20	<1	<1	<1
12N/18E-35Q01	08-16-89	14.5	1,120	7.3	2.7	--	--	3.80	<1	<1	<1
	08-30-89	14.5	1,020	7.2	2.8	--	--	4.30	<1	<1	<1
12N/18E-36J01	08-16-89	15.5	370	7.6	--	--	--	2.70	<1	K5	<1
	08-25-89	13.0	352	7.0	9.2	--	--	2.50	<1	<1	<1
12N/19E-19N01	08-15-89	17.5	430	8.0	0.3	0.050	<0.20	<0.10	<1	<1	<1
12N/19E-20E01	08-23-89	14.5	158	8.4	1.1	0.010	<0.20	<0.10	<1	<1	<1
12N/19E-20F01	08-23-89	15.0	149	8.6	0.2	<0.010	<0.20	<0.10	<1	<1	<1
12N/19E-20M01	08-24-89	14.0	167	8.4	0.6	<0.010	<0.20	<0.10	<1	<1	<1
12N/19E-20P02	08-23-89	15.0	228	6.8	2.1	<0.010	0.40	0.40	<1	<1	<1
12N/19E-28N01	08-24-89	15.5	315	7.6	0.2	0.010	1.0	<0.10	<1	<1	<1
12N/19E-29B03	08-23-89	15.5	375	7.7	0.7	<0.010	<0.20	<0.10	<1	<1	<1
12N/19E-29B04	08-30-89	14.5	648	7.6	0.0	0.010	0.20	<0.10	<1	<1	<1
12N/19E-29G01	08-10-89	14.0	887	7.5	4.1	--	--	5.70	K4	K5	K1
12N/19E-29G02	08-10-89	15.5	430	7.3	5.6	--	--	0.70	<1	7	K1
12N/19E-29G03	08-24-89	13.5	680	8.0	0.3	0.010	0.30	<0.10	<1	K5	<1
12N/19E-30G01	08-24-89	15.5	298	8.0	3.1	--	--	<0.10	<1	<1	<1
12N/19E-30L01	08-16-89	14.0	320	7.5	4.2	--	--	1.10	<1	<1	<1
12N/19E-30L02	09-13-89	15.5	419	7.9	0.0	0.030	<0.20	<0.10	<1	K1	<1
12N/19E-32G01	09-11-89	15.5	297	7.9	3.7	--	--	<0.10	<1	<1	<1
12N/19E-32H01	09-11-89	14.5	271	7.4	4.9	--	--	1.50	<1	<1	<1
12N/19E-32H02	09-11-89	15.0	261	7.4	4.9	<0.010	<0.20	1.40	<1	<1	<1
12N/19E-32K01	08-25-89	15.0	227	6.7	5.6	--	--	2.20	<1	<1	<1
12N/19E-32N01	09-11-89	15.0	214	7.1	6.4	--	--	1.60	<1	<1	<1
12N/19E-32R01	08-25-89	17.0	270	6.6	6.8	--	--	3.70	<1	K5	<1
12N/19E-33D01	08-10-89	15.0	265	7.3	4.1	<0.010	0.70	1.30	<1	<1	<1

Appendix 2.--*List of surface-water site names and site numbers*

Site number	Identification number	Site name
1	462258120450801	Agency Creek at Highway 220
2	462640120311801	Drain 2 at Lateral C
3	462602120233501	Drain 2 above Wanity Slough
4	462351120220601	Drain 3 at Highway 97 near Toppenish
5	462206120265301	Drain 4 near Ashue Road
6	462207120321701	Drain 4 near Harrah Road
7	462205120195401	Drain 4 near Wanity Slough
8	461931120261701	Drain at Campbell Road into Marion Drain
9	12506900	Drain at Evans Road near Mountain View School near White Swan
10	461927120190801	Drain at Highway 97 into Marion Drain
11	462206120265401	Drain into Drain 4 near Ashue Road
12	462207120235001	Drain into Drain 4 near McKinley Road
13	462206120220001	Drain into Drain 4 near Olden Way
14	462803120333001	Drain near Decker Road and Deering Road
15	462629120304201	Drain to Drain 2 near Lateral C
16	462206120280301	Drain to Drain 4 near Lateral A
17	12505350	East Toppenish Drain at Wilson Road near Toppenish
18	462230120335001	Harrah Drain at Fort Road
19	12505466	Harrah Drain at Harrah Drain Road at Harrah
20	462112120335001	Harrah Drain near Marion Drain at Harrah Drain Road
21	462238120323401	Marion Drain at Harrah Road near Harrah
22	461927120191001	Marion Drain at Highway 97
23	12505510	Marion Drain at Indian Church Road at Granger
24	462203120363401	Mud Lake Drain at Piute Lateral
25	12506300	North Fork Simcoe Creek near Fort Simcoe
26	462312120371701	Olney Flat Drain at Simcoe Creek
27	12506330	South Fork Simcoe Creek near Fort Simcoe
28	462327120385401	Simcoe Creek at Barkes Road
29	462341120433801	Simcoe Creek at White Swan
30	462342120483501	Simcoe Creek above Spring Creek
31	462517120254201	Small Drain into Drain 2 near Highway 97
32	462351120222301	Small Drain into Drain 3 at Olden Way near Toppenish
33	12505410	Sub 35 Drain at Parton Road near Granger
34	461830120200701	Toppenish Creek - 1/4 mile above Highway 97
35	462232120382401	Toppenish Creek at Fort Road
36	461924120311601	Toppenish Creek at Lateral C
37	12507508	Toppenish Creek at Indian Church Road near Granger
38	12507200	Toppenish Creek at Island Road near Harrah
39	462110120411501	Toppenish Creek near Shaker Road
40	12506000	Toppenish Creek near Fort Simcoe
41	12507150	Tributary to Mill Creek at Tecumseh Road near White Swan
42	462235120385101	Tributary to Toppenish Creek near Fort Road
43	12505469	Unnamed Drain at Becker and Yost Roads near Toppenish
44	12505468	Unnamed Drain at Fort Road near Harrah
45	12503640	Unnamed Drain at Lateral 1 and Riggs Roads near Wapato
46	12507050	Unnamed Drain at Progressive Road near Harrah
47	12505475	Unnamed Drain at Yethonat at Branch Road near Wapato
48	12505467	Unnamed Drain to Marion Drain near Harrah
49	12505470	Wanity Slough at East First Street at Wapato
50	12505482	Wanity Slough at Meyers Road

Appendix 3.--*Surface-water-quality data, October-November 1989*

[Deg C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°Celsius; mg/L, milligrams per liter; cols./100 ml, colonies per 100 milliliters; <, less than; --, constituents not analyzed for; E, estimated number based on count of only part of the plate; K, number based on count outside of ideal range]

Site number	Date	Time	Discharge (cubic feet per second)	Temperature water (Deg C)	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Nitrogen, NO_2 +NO_3 dissolved (mg/L as N)	Nitrogen, ammonia+ organic dissolved (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Coliform, fecal, (cols./ 100 ml)	Streptococci, fecal, (cols./ 100 ml)	*Escherichia coli* (cols./ 100 ml)
1	11-01-89	1630	1.17	9.0	210	7.6	10.7	0.35	--	--	32	140	K7
2	10-25-89	1145	4.90	12.7	321	7.8	10.8	1.50	--	--	36	190	48
3	10-25-89	1700	6.51	13.6	281	8.1	11.8	3.20	--	--	K14	82	K8
4	10-27-89	1330	6.58	14.0	218	7.5	8.7	1.80	0.60	0.01	41	220	34
5	10-31-89	1655	13.2	14.0	282	7.5	11.2	2.90	--	--	28	180	K7
6	10-27-89	1050	0.22	8.7	342	7.7	8.6	4.90	--	--	K14	170	K6
7	10-31-89	1445	14.4	12.7	288	7.8	11.6	3.90	--	--	K13	190	K21
8	10-24-89	1530	10.6	14.6	302	8.0	10.0	4.60	--	--	67	150	49
9	10-24-89	1210	0.31	10.3	1,360	8.1	8.8	0.28	--	--	210	5,000	280
10	10-24-89	1430	11.1	13.7	293	8.4	12.7	4.10	--	--	120	160	K73
11	10-30-89	1505	0.47	12.3	241	9.1	14.2	3.00	--	--	48	E4,700	K13
12	10-31-89	1100	2.12	13.3	270	8.1	12.8	2.90	--	--	21	120	K11
13	10-31-89	1230	0.36	11.3	236	9.1	16.2	3.00	--	--	K5	150	K9
14	10-24-89	0920	0.16	7.2	1,560	8.1	8.6	0.29	--	--	130	4,900	150
15	10-25-89	1610	0.64	11.3	220	7.7	9.2	1.30	--	--	23	260	24
16	10-27-89	1220	0.30	11.3	220	7.6	9.4	1.70	--	--	K5	520	K6
17	10-30-89	1615	19.2	14.7	305	7.3	5.7	4.40	--	--	K2,500	520	K1,000
18	10-25-89	1210	12.3	13.5	385	7.9	11.3	6.00	--	--	57	30	20
19	10-26-89	1110	2.96	12.8	332	7.9	9.7	5.50	--	--	61	120	70
20	10-25-89	0945	28.9	11.5	406	7.9	8.8	5.80	--	--	K62	78	29
21	10-25-89	1110	3.65	13.5	366	6.9	6.2	6.00	--	--	22	570	K8
22	10-24-89	1100	222	12.5	348	7.9	9.0	4.20	--	--	120	240	56
23	10-23-89	1600	343	13.8	315	8.0	8.8	3.60	--	--	320	920	K60
24	10-25-89	1500	17.9	13.3	592	8.3	12.3	3.20	0.60	0.02	100	240	71
25	10-26-89	1050	4.09	7.2	161	8.0	10.8	<0.10	--	--	K15	54	K15
26	11-01-89	1315	13.7	11.0	457	8.5	13.8	1.20	--	--	67	K65	K3
27	10-26-89	1255	3.64	7.1	130	7.8	--	<0.10	--	--	97	330	68
28	11-01-89	1550	8.60	9.1	348	8.0	--	0.57	--	--	K21	130	K12
29	11-02-89	1500	4.83	7.1	289	8.0	10.4	0.25	--	--	150	590	80
30	11-01-89	1240	1.19	5.4	219	7.9	11.4	<0.10	--	--	180	93	77
31	10-27-89	1000	0.63	12.6	222	7.1	5.6	1.80	--	--	22	200	K19
32	10-27-89	1150	3.55	15.0	192	7.6	7.2	1.60	--	--	67	200	46
33	10-31-89	1500	26.8	13.6	242	7.9	10.2	2.50	--	--	200	230	110
34	10-24-89	1215	31.6	9.5	497	8.1	8.8	0.12	--	--	100	96	38
35	10-26-89	1200	1.23	9.2	226	8.0	9.5	<0.10	--	--	80	K1,700	53
36	11-02-89	1300	35.6	7.2	515	8.1	9.8	0.77	--	--	K20	85	K14
37	10-24-89	1000	56.3	9.8	426	8.1	9.3	1.30	--	--	320	460	250
38	10-26-89	1445	51.8	11.2	508	8.2	10.0	1.70	--	--	210	160	120
39	11-02-89	1540	0.49	4.8	165	7.7	11.4	<0.10	<0.20	<0.01	K12	39	K14
40	11-01-89	1440	17.4	6.4	142	7.9	12.0	<0.10	--	--	K3	K6	K4
41	10-26-89	1545	0.13	10.9	1,510	6.0	11.4	3.20	--	--	K5	67	K4
42	10-24-89	1630	3.22	10.6	367	7.8	9.5	0.12	--	--	120	290	74
43	10-31-89	1100	9.33	12.3	310	7.6	9.9	4.40	--	--	54	240	33
44	10-26-89	0950	2.06	15.7	342	6.6	3.8	0.41	--	--	110	210	83
45	10-23-89	1510	0.50	11.7	1,440	7.9	6.4	0.58	--	--	3,300	29,000	2,000
46	10-26-89	1600	3.22	11.5	665	8.2	9.4	1.10	0.60	0.04	77	250	130
47	10-27-89	1010	0.67	10.6	230	7.5	7.1	2.10	--	--	54	250	43
48	10-26-89	1355	1.56	13.3	285	7.4	5.5	3.20	--	--	K14	51	K10
49	10-31-89	0925	0.25	3.3	179	7.7	9.6	0.37	--	--	28	56	K15
50	10-31-89	1300	72.4	13.2	245	7.5	9.2	2.40	--	--	150	130	110

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Well locations and sampling phase--PLATE 1
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NITRATE-FERTILIZER APPLICATION RATES FOR THE TOPPENISH CREEK BASIN, WASHINGTON, (SMALL AND JAMESON, 1989); NITRITE-PLUS-NITRATE NITROGEN CONCENTRATIONS IN WELLS TAPPING THE YOUNG VALLEY FILL AQUIFER

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WATER-RESOURCES INVESTIGATIONS REPORT 97-4194
Fertilizer application rates and nitrogen concentrations in old valley fill wells--PLATE 4
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Fertilizer application rates and nitrogen concentrations in basalt wells--PLATE 5
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